JACET Journal of Advances in Computer Engineering and Technology, 3(4) 2017

A Genetic Based Resource Management Algorithm Considering Energy Efficiency in Cloud Computing Systems

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Received (2017-03-17)
Accepted (2017-09-12)

***Abstract* - Cloud computing is a result of the continuing progress made in the areas of hardware, technologies related to the Internet, distributed computing and automated management. The Increasing demand has led to an increase in services resulting in the establishment of large-scale computing and data centers, in addition to high operating costs and huge amounts of electrical power consumption. Insufficient cooling systems and inefficient, causing overheating sources, shortening the life of the machine and too much carbon dioxide is produced. In this paper, we aim to improve system performance; Cloud Computing based on a decrease in migration of among virtual machines (VM), and reduce energy consumption to be able to manage resources to achieve optimal energy efficiency. For this reason, various techniques such as genetic algorithms (GAs), virtual machine migration and ways Dynamic voltage and frequency scaling (DVFS), and resize virtual machines to reduce energy consumption and fault tolerance are used. The main purpose of this article, the allocation of resources with the aim of reducing energy consumption in cloud computing. The results show that reduced energy consumption and hold down the rate of virtual machines breach of contract, reduces migration as well.**

***Index Terms* - Cloud computing, Energy efficiency, Genetic algorithm.**

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I. INTRODUCTION

Cloud computing is one of the newest phenomena in the field of information technology which can be of different services around the world and at any time put at the disposal of users and make other users worry about details and not system implementation [1] [2]. Cloud computing using virtual devices to reduce server power costs and to minimize the cost of the hardware. Furthermore, Large-scale data allows users to store up data access [3]. The role of virtual machines has emerged as an important issue, because through virtualization, technology can be more scalable cloud computing infrastructure [3]. Virtualization technology allows one to create several Virtual Machines (VMs) on a physical server and, therefore, reduces amount of hardware in use and improves the utilization of resources [4]. However, the most serious problem facing cloud suppliers, energy consumption is discussed. With the advent of cloud computing, using data centers and virtualizes environments with large-scale, quickly became popular in the computing industry [4] [5]. Cloud Contains of data centers than to continue its operations need a lot of energy. High-energy consumption not only increases the cost and reduces the cloud provider's profit but also intense emission of carbon dioxide, which is as well very harmful to environment [6] [7] [8]. Furthermore, large-scale enforcement of high-energy consumption in a cloud environment, such as reducing the reliability to the system makes problems [9].

One of the problems during recent years the field of cloud services without the use of machines for processing data, That due to high carbon dioxide produced by these devices and high-energy consumptions and migration from one machine to another without managements, To manage in this area in order to reduce energy consumption according to adhere to Service Level Agreements (SLA) considered [10] [11]. High availability in cloud computing systems is essential to maintaining customer satisfaction and avoiding revenue loss because of service level agreement (SLA) violation penalties [12]. Properly allocate to virtual machines enable applications that immigration dropped and reduce energy consumption and ultimately optimize resource management. This article, Allocation of resources with the aim of reducing energy consumption in cloud computing is proposed. In this paper, we discuss the proposed strategy to reduce energy consumption and minimize migration between virtual machines pay. For this purpose the full review all the functions needed and outlines the proposed approach for the purpose of paid and full description of the application CloudSim and style simulation software in a cloud environment using genetic algorithm is provided. Whether we can use genetic algorithms to reduce energy consumption in a cloud environment to achieve maximum efficiency. Discussion is an Iaas system environment for a heterogeneous data center includes physical node N, is shown. Provided for the implementation of software algorithms and libraries' net beans used CloudSim. First, to explain the important functions and elements in the simulate CloudSim, then the Genetic algorithm to implement the program order to allocate resources to reduce energy consumption and migration between virtual machines used will be discussed.

The remainder of this paper is organized as follows: we address the related work in section II. The system model including Datacenters model, jobs and virtual machines model, energy model, are described in Section III. A proposed method for migration virtual machines in the cloud environment processors will be offered in Section IV. In the Section V, Genetic Algorithms is described. The Structure of Genetic Algorithms including Chromosome, population and Fitness Function and Work Functions () and Genetic Operators are described in Section VI. Experimental results are provided in Section VII. Finally, Section VIII concludes the paper.

II. RELATED WORK

This section discusses work that is related to that described in the paper, many methods have been proposed for power management at the server level. Some methods based servers provisioning energetically act in this way. Servers can be turned on and off dynamically as required [13] [14] [15]. The authors in [16] the supply and control server by using the data center is considered DVFS, and it has been formulated and three control loop analysis technique based on queue and practices and practices have used a combination of the two. In [17], DVFS technique has been used for provisioning of real-time virtual machines in Cloud datacenters. In [18], which defines a method is provided for Timing input tasks, how many servers in each datacenter must be enabled and the contribution of each entry is the data center load. In [2] a technique is provided for resources and virtual machines that automatically adapt to the changes and a guaranteed quality of service to the end user offers. In [9] several methods have been proposed initiative to integrate who are trying to increase the efficiency of resource use. In [19] [20], online migration of jobs between datacenters have been presented in order to conform to variation of energy pricing. Designing and deploying of fault-tolerance techniques like migration and replication is popular to handle reliability challenges in current distributed systems [21]. [22] Has introduced some of the existing fault tolerance approaches for a cloud environment [23] has evaluated fault tolerance models based on resource consumption and mean execution time metrics as well. For this reason, the proposed method used techniques such as migration of virtual machines, methods DVFS, resize machines and genetic algorithms to reduce energy consumption and fault tolerance. Because the algorithms that are used by resizing virtual machine's infringement amounts lower than expected when compared other methods, for this reason they are capable of matching processor with variability in the productivity and reduce the risk of violation of the deadline. This method has the advantage over existing methods is that a compromise between energy management and event error is established in a cloud environment, and reduces both energy consumption and the number of migrations.

III. SYSTEM MODEL

3.1 datacenter Model

For modeling the infrastructure-level services in the simulator, we can improve the availability of the datacenter. Existence Datacenter a large number of existences such as host manage. These hosts according to the virtual machine allocation policy are defined by the cloud service provider, assigned to virtual machines.

In this simulation, each entity is an example of a component. CloudSim could be one element a class, or a set of classes that a model in CloudSim show. Reduce datacenter energy of issues in the field of cloud computing is important because it makes a lot of electricity be consumed.

In this paper, as depicted in Fig 1 a datacenter defined that there are a number of hosts within the datacenter, that hosts put together and a data center to be created.

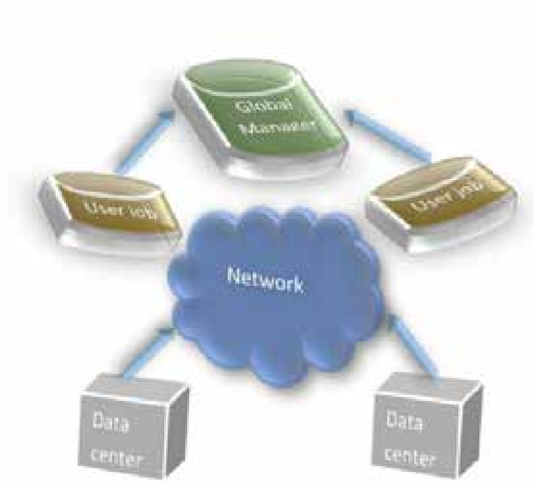


Fig.1. Datacenters Model in Cloud Environment [20].

In this class, the amount of memory and processing power and the number of CPU, etc. are defined. The existence of database, modeling a number of host existences. In this article, we define a max power, and we define a threshold 70% for power, consumption in the data center, In fact, 70% of the max power that can be consumed.

3.2. Hosts and Virtual Machines Model

Host's number or physical machine put together, and constitute the data center. Each host will be given to one or more virtual machines. In each of these hosts, there are a number of CPU, STORAGES, RAM.

In order to simulate policy's preparation under different levels of performance that are distinct from one another, CloudSim preparation simulator supports virtual machines on two levels [11] [24]. The first we start the host level and then at the level of the virtual machine. At the host level, we define, how much of the total processing power core will be assigned to each virtual machine. In the virtual machine, each virtual machine a fixed amount of processing powers available to individual application services on which it is located, allocates. VM are on the host and have access to the memory and processor host.

The properties that must be defined for a VM:

1) MIPS: It specifies the number of CPU calculations per second.

2) RAM: The amount of memory.

3) BW: Bandwidth

Therefore, 10 have defined that this specification for the VM virtual machine is different. It is assumed that each job is assigned to only one virtual machine. These virtual machines must meet the deadline constraint of the submitted job. Therefore, each VM could be modeled as the following [21]:

$$VM_i(m_i, r_i, d_i), \qquad (1)$$

Where m_i indicate the computational capacity of *ith* virtual machine, which is expressed in Million Instructions per Second (MIPS). In this model r_i and d_i represent the amount of requested RAMs and the deadline of ith VM, respectively. The execution time each job on its assigned virtual machine could be calculated as the following [25]:

$$e_i = \frac{l_i}{m_i}, \qquad (2)$$

It should be noted that a change of computational capacity of ith VM by applying the VM, resizing technique in order to prevent the SLA violation will change the execution time of the VM [21].

3.3. Cloudlet and Datacenter Broker Model

This class, working models of a variety of tasks that enters the system perform. CloudSim any program by the specified amount of data transferred, and processed volume will be determined before running. In fact, the piece clouds are the tasks that are performed in the cloud. Cloudlet and tasks within defined VM it must be created based on input tasks. Users submit their jobs to the global manager with a hard real-time model. In this model, each job has a deadline by which it should be finished, and the job is profitable for the cloud provider as long as it is completed before its deadline. Furthermore, each job has a number of instructions that should be executed such that each job is modeled as the following [25]:

$$job_i\,(l_i, d_i), \qquad (3)$$

Where l_i and d_i indicate the number of instructions of *ith* job in Million Instructions (MIs) and the deadline of the submitted job, respectively. Cloud provider employs appropriate virtual machine for each job [21]. It is assumed that each job is assigned to only one virtual machine [21].

In this article, we define 10 cloudlet that their properties are different. The following properties are defined for each cloudlet:

1) Length Task (number needed to run a cloud computing.)
2) File Size Task (size cloud specifies that the input data to the cloud.)
3) Output Size Task (output size cloud does indeed specify the output size will be in the cloud.)

Cloudlet allocated to virtual machines is an important item which is a significant item which is then the resources. Due to the different characteristics that each passenger and each virtual machine the best car for each cloud should be considered, with the correct allocation can be reduced immigration.

In this article, we developed a genetic algorithm that uses of the history and current demand for the allocation. Broker task is that work (cloudlet) to run the virtual machines.

For example, broker cloudlet one for 1 the machines assigned to run located on host 2. Broker is a provider who is optimized shielding the network. The broker will reduce the total power network.

3.4. power data center model

Datacenters managed and operated by network providers form a significant part of the current Internet infrastructure, as there is a large number of such datacenters that are almost ubiquitous across the world [26]. Due to the large number of host connections in data centers to provide cloud services as well as the cooling system to cool the hosts, amounts of electrical energy to supply these are systems increases operating costs [27]. Related topic, carbon dioxide) CO2(emissions that may be harmful to the physical environment because of greenhouse effects.

Simulator models and entities CloudSim basis for the assessment and validation of algorithms and techniques to power conscious offers. Members method simulator must get Power () of this class rewrites the input parameters of productivity and output parameter the amount of power consumption is the present host.

3.5. Energy Model

Processors are the most important factor of energy consumption in data centers. The CPU power consumption can be attributed to dynamic and idle power of the CPU [21]. Accordingly, the total power consumption of CPU could be modeled as [28]:

$$P_i = \beta_i + \alpha_i f(t)^3, \qquad (4)$$

Where β_i and α_i denote the idle power consumption and proportional coefficient, respectively. Furthermore, *f(t)* indicates the frequency level of CPU at the time instant of *t*. Each CPU is equipped by DVFS and could adjust the frequency level of CPU in one of the operating points between maximum and minimum frequencies. DVFS method to control the power consumption of CPUs is an optimal way [5]. DVFS method this DVFS method that allows the processor with a run a frequency level appropriate for executing a task, be able to save energy [29] [30]. Hence, the energy consumption of CPU could be calculated as [17]:

$$E_i = \int_{t_0}^{t_1} P_i\big(f(t)\big)dt\,, \qquad (5)$$

The energy consumption can vary at different time intervals because the frequency level of the CPU can change between various operating points [21]. So to find an optimal frequency of the processor to reduce energy consumption and increase performance, is a crucial issue [31].

The global manager calculates minimum MIPS required to meet given deadlines at current time tcur according to the parameters of each job as the following [21]:

$$m_{low} = min\left\{m_i \middle| m_i \geq \frac{l_i}{d_i}\right\}, \qquad (6)$$

Where m_low is equal to the minimum amount of MIPS could complete the job before the given deadline if the utilization of its virtual machine should be complete. Because the utilization of CPU is variable over time, this MIPS cannot guarantee meeting the deadline [21].

Therefore, computational capacity of each virtual machine should be overestimated as the following [21]:

$$m_i = E \times m_{low}, \qquad (7)$$

Where E represents the Error Factor for overestimating the VM size to handle the expected faults. Subsequently, the global manager could distribute virtual machines among data centers based on their required MIPS [21]. The main goal of the global manager is allocating each virtual machine to a Physical machine in the cloud environment that could schedule assigned job and has minimal increase in the energy consumption rate [21].

IV. Problem Description

Appropriate allocation of applications to virtual machines this allows the migration decreased and reduced energy consumption and finally optimize resource management. In the following a migration of virtual machines in between processors cloud environment, to overcome fault event and prevent SLA violations provided considers that limits energy consumption. The main objective of this article, program resource allocation with the based on reduction of energy consumption and based on decrease in migration between virtual machines. The main argument to reduce energy consumption, SLA and genetic algorithms. The proposed method is the use of genetic algorithms and DVFS. To enter Genetic Algorithm must first price to be determined this is done through CloudSim. CloudSim also studied in two parts. Energy and SLA they must be considered that the total minimum.

4.1. SLA

Knowing how many of the total number of applications to run on the server have found. Most power through the host all hosts will be determined within the data center. Given that how many of these requests let's find CPU usage; per host Sum it up in total we requested. With this split the cost function the minimum is calculated.

$$\text{Cost} = \frac{1}{\text{Total allocated}}, \qquad (8)$$

V. GENETIC ALGORITHM

The main idea of theory of Darwinian evolution GA in year (1859) was taken. Darwin's theory of evolution is natural that those traits that are more consistent with natural laws. Chances of survival are greater. A GA is an optimization algorithm which uses principles inspired in nature to "evolve" toward a best solution [32]. Genetic algorithm is a heuristic search that is based on the process of natural evolution [33]. Genetic algorithm belongs to the larger class of evolutionary algorithms, which generate a solution to optimization problems using techniques inspired by natural evolution such as inheritance, mutation, selection and crossover [34]. Briefly In each generation better species reproduction given the opportunity (Elitism), and species with undesirable characteristics to gradually destroy. As a result, over time, People of different generation's evolution find.

VI. The Structure of Genetic Algorithms

In general, genetic algorithms are comprised of the following components.

6.1. Chromosome

In genetic algorithms, each chromosome represents a point the search space, and a possible solution to the problem are desired. These chromosomes a fixed number of genes are formed. For show chromosomes, usually binary coding (string nose) is used. Chromosomes represent tasks with different sizes. Jobs in the simulator are the same as Cloudlet.

6.2. population

Set of chromosomes constitute a population. With the impact of genetic operators on each population, new population with the same number of chromosomes is formed.

6.3. Fitness Function

In order to solve any problem by using genetic algorithms, must first have a Fitness function problem to invent it. In this paper, the amount of energy fitness functions and the number of migration that after the simulation simulator based on chromosome data to calculate the amount of emphasis in this article Cost fitness function is the same Fitness function. Within this function, a Create Task is there.

In this paper for each Task a Length, File size and Output size we entered differently if desired. In this paper, 10 Task cases with characteristics are defined. In addition, in the cost function also have a Create VM is distorted that list of machines created, and we applied to each of the virtual machines with different properties. Such as MIPS, BW, RAM, SIZE is defined. (The amounts and numbers are randomly and are planned to test only).

6.4. Work function ()

Then the following functions and applications used in this article are fully will be explained. The proposed algorithm in cloud computing environment is shown in figure 2.

```
public class Genetic_ {

        private static List<Cloudlet> cloudletList;

        private static List<Vm> vmList;

        public static void main(String[] args) {
                int generation=20;
                first();
                sort_people();
                for(int i=0;i<generation;i++);
                {
                    crossover();
                    sort_people();
                    mutation();
                    selection();
                }
                    sort_people();
                    cost_show(0);
}
```

Fig.2. The GENETIC algorithm.

6.4.1 Work Function First()

In this function, we'll create an initial population for the genetic algorithm. This function randomly creates different virtual machines. Chromosome's number is the number of job. Everyone from the population represents a job. As a result, we determine people from pop size to cloudlet number. Everyone randomly allocated to a virtual machine. Then we calculate the cost for everyone. You can see the cost of individual in the following formula.

$$\text{Cost people} = \text{SLA} + \text{Get Power}(), \qquad (9)$$

6.4.2. Work Function Sort People()

After the population by function First() Created, we sort People() with Quick Sort in the following formula.

$$\text{If Cost people}[j] > \text{Cost people}[j+1], \qquad (10)$$

6.4.3. Work Function Crossover()

In this paper, combined action to be the first person population with the rest of the people composition.

6.4.4. Work Function mutation()

For practice jumps an individual randomly or a random Cloudlet and a random VM will be selected.

6.4.5. Work Function Selection ()

The practical choice in which the next generation of chromosomes from current population according to the law of survival are determined, this is the most important step in genetic algorithm and an important role in this process offers.

6.5. Genetic operators

In genetic algorithms, during the reproductive phase the genetic operators are used. The effect of this operator on a population, its next-generation population is generated. Operator's selection, crossover or mutation are the most commonly used in genetic algorithms. Therefore we used in their own work of these three genetic operators.

6.5.1. crossover

The performance of a genetic algorithm is dependent on the genetic operators, in general, and on the type of crossover operator, in particular [35]. In this paper, the method used Uniform crossover. The algorithm works this way. A random chromosome called the Mask the length of the chromosomes existing production. Mask chromosome determines which one genes from the first parent and which one genes to be transferred from the second parent to a child. Bit Density, Determinant the role of each parent in the child's characteristics.

6.5.2. Mutation

After completion of the operation crossover, the mutation operator on chromosome be given effect. Mutation adds value to GA by introducing random change, which could assist in overcoming local minima in the search exploration [36]. A gene from a chromosome randomly selected and then the content of gene change be given. If the gene is made of binary numbers, Gets reverse it and if belong to be a collection, the gene or another element. Instead of it puts.

6.5.3. selection

The operator among Chromosome in a population, the number of chromosomes chooses for reproduce. More graceful have a higher chance to be selected for breeding. In this study, were used Elitism Selection. Selection based the best when the genetic operators (crossover and mutation) are used, the chromosomes may be lost.

Elitism a method for keeping a copy of the chromosomes in the new generation.

VII. EXPERIMENTAL RESULT

7.1. Simulation Setup

In this paper, the CloudSim simulator is used the simulation of data centers and cloud environment. To accomplish this, the following components were added to our simulator model:

1) DVFS model and frequency levels

2) Migration of virtual machines

Discussion is Iaas system environment that Datacenters with different characteristics are defined. Datacenters are inhomogeneous with respect the number of hosts and the number of processors. However, the processing power of CPUs in the datacenter is different. Cloudlets are given to m virtual machines with the following characteristics:

1) MIPS: It specifies the number of CPU calculations per second.

2) RAM: The amount of memory.

3) BW: Bandwidth

The jobs follow the hard real time model, such that, a job is profitable for the provider when it is accomplished before its deadline. In server failure occurrence, all running virtual machines on the server are unable to continue their running and should be migrated to another physical machine; otherwise, they must be waiting until the repair time is finished. Max power, a threshold 70% for power consumption in the data center we define. Max power is equal 250, is considered the most power host. Processor power (1000, 2000, 3000) is considered. The number of processor is 3. Furthermore, it was assumed that the utilization of CPU for each virtual machine is variable. Power, The amount of RAMs for each virtual machine are selected, RAM is equal 10,000. Storage memory Hard= 1000,000. Available bandwidth between each of them is, BW= 100,000. 64-bit CPU Linux operating system and the type of machine are the kind of Zen. Time zone= 10, cost=3, Cost per men=0.05 Amount to be paid per unit of RAM. Cost per storage= 0.001 the value per unit the use of hard and cost per BW=0 Cost per byte of use efficiency. Create VM, to manually create up to 10 virtual machines and for each of them RAM=128, MIPS= (250, 500, 750, 1000), BW=2500, size=2500, CPU=Zen processor. Each chromosome of a number VM and each gene is the job number.

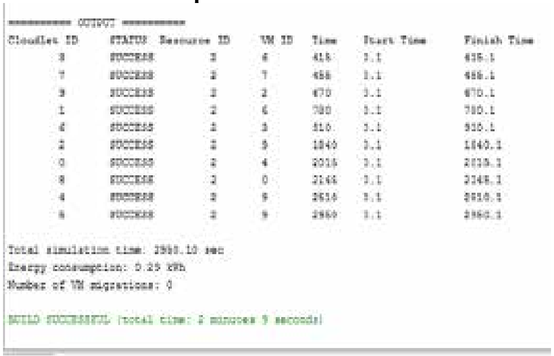
7.2. Simulation Results

In this paper, first obtained results without discussed Genetic Algorithm, and the next stage of Genetic Algorithm, we used to improve the system.

Table 1 shows an example from the results generated by the software.

For evaluation, first using algorithms DVFS and The results of tests conducted are shown Table 2. The number of jobs, machines and Experiment is 10 considered and in best situation, the energy is 0.28 kWh.

TABLE I
Output in the simulator.



```
========== OUTPUT ==========
Cloudlet ID    STATUS  Resource ID   VM ID   Time   Start Time   Finish Time
     3         SUCCESS      2          6      415     0.1          415.1
     7         SUCCESS      2          7      456     0.1          456.1
     9         SUCCESS      2          2      670     0.1          670.1
     1         SUCCESS      2          6      780     0.1          780.1
     [illegible] SUCCESS    2          3      910     0.1          910.1
     2         SUCCESS      2          5      1840    0.1          1840.1
     0         SUCCESS      2          4      2015    0.1          2015.1
     8         SUCCESS      2          0      2146    0.1          2146.1
     [illegible] SUCCESS    2          [illegible] [illegible] 0.1 [illegible]
     [illegible] SUCCESS    2          9      2960    0.1          2960.1

Total simulation time: 2960.10 sec
Energy consumption: 0.29 kWh
Number of VM migrations: 0

BUILD SUCCESSFUL (total time: 2 minutes 9 seconds)
```

TABLE II
Amount of energy used by applying the algorithm DVFS to the Number of 10 Experiment

Experiment	suggested method kwh	VR(DVFS)kwh
1	0.29	0.32
2	0.32	0.32
3	0.42	0.6
4	0.38	0.41
5	0.28	0.30
6	0.43	0.54
7	0.31	0.41
8	0.34	0.34
9	0.28	0.35
10	0.32	0.32

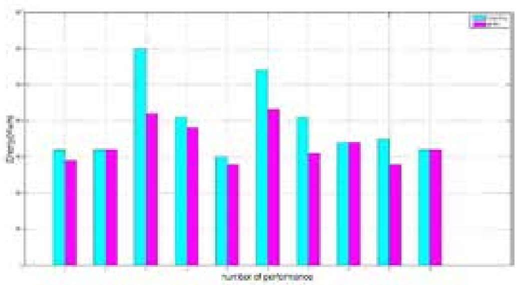


Fig. 3. The amount of energy in 10 tests.

We saw the results of the suggested method and VR (DVFS) algorithm with 10 experiments in fig 3. In the best situation, Energy consumption is 0.28 KWh. Now we do this assessment by using the genetic algorithm and DVFS. The simulation results shown in Fig 3, Fig 4, Fig 5. The initial population on the run 10 are assumed; and run number respectively 30, 50 and is 70.

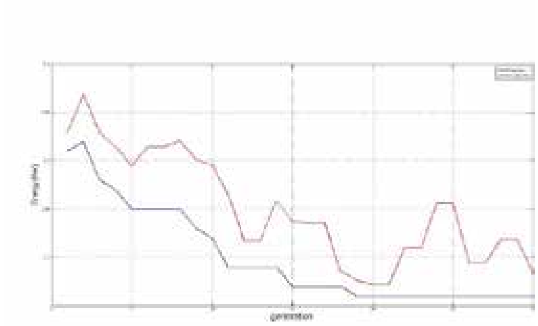


Fig. 4. Number of repetitions 30.

Figure 4 shows, the final value and best result for energy are obtained 0.16 kWh. It should be noted that number immigration is zero; acceptable outcome for this simulation. According to the charts on repeat 18 to 30 the amount of energy calculated on a constant basis but at a distance of 1 to 18 this decline so reduction was descending. In the last 12 repeat to a steady state is reached. This experiment was repeated on 30; and the first amount of energy was 0.31kwh; this amount is reduced to the 0.15 kWh. It Reached To 0.16 kWh in the implementation of the 30th which is a significant reduction.

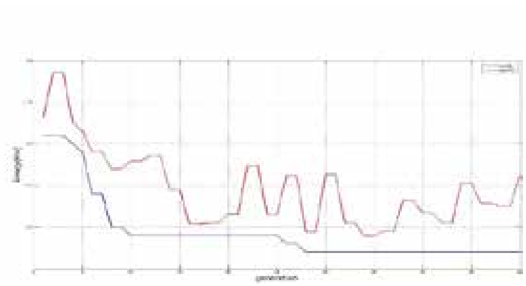


Fig.5. Number of repetitions 50.

Figure 5 shows, the final value and best result for energy are obtained 0.17 kWh. It should be noted that number immigration is zero; acceptable outcome for this simulation. According to the charts on repeat 28 to 50 the amount of energy calculated on a constant basis. These algorithms are finally able to gain the absolute minimum. Given that energy is calculated in the first iteration 0.31 kWh; however, in the end, this amount has dropped to 0.17 kWh; that the amount of the Reduction is equal to 0.14 kWh and this is a good result.

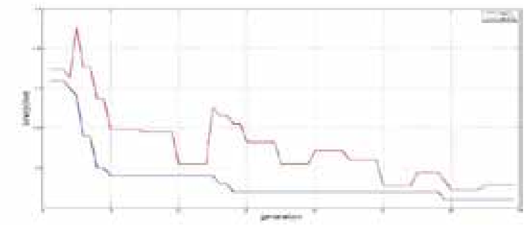


Fig. 6. Number of repetitions 70.

As depicted in Fig 6, the final value and best result for energy are obtained 0.16 kWh. Number of immigration is zero; acceptable outcome for this simulation. Given that energy is calculated in the first iteration 0.31 kWh; however, in the end, this amount is reduced to 0.16 kWh. The amount of this Reduction is equal 0.14 kWh. Repeat 70 compared to 50 reps is better reduction.

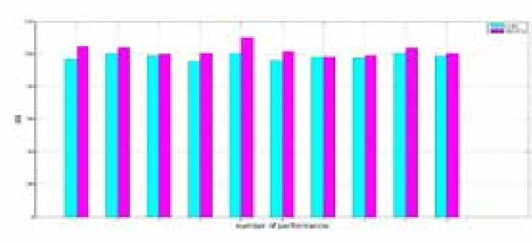


Fig.7. The SLA violations for both algorithms implemented in 10.

Figure 7 shows the results of both algorithms per SLA parameters. It is seen that the proposed method the violation of SLA is less compared to VR -DVFS.

VIII. CONCLUSIONS

The most serious problem has faced cloud suppliers is energy consumption in data centers. As a result, to reduce energy consumption in cloud environment, we used of combination DVFS and GA in this study, we could by assigning suitable each cloudlet to virtual machines. Energy consumption in cloud environment has considerably reduced; and with the assign immigration will also be reduced. In this paper, we consider the lowest increase in energy consumption, and the minimum deadline misses ratio as the most significant factors for migration of each VM. Our method could achieve low SLA violation with the least amount of energy consumption compared to other proposed methods. We can be presented with recovery algorithms for multiple purposes such as topics as reduce the cost of services provided looked closer to see.

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