Energy aware computing resource allocation using PSO in cloud

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DEPARTMENT OF INFORMATION TECHNOLOGY

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Energy aware computing resource allocation using PSO in cloud

Major Project

Submitted in partial fulfillment of the requirements

for the degree of

Master of Technology in Computer Science and Engineering (Networking Technologies)

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Certificate

This is to certify that the major project entitled **"Energy aware computing resource allocation using PSO in cloud"** submitted by **Vanita Chaudhrani (16MCEN04)**, towards the partial fulfillment of the requirements for the award of degree of Master of Technology in Computer Science and Engineering (Netwoking Technologies) of Nirma University, Ahmedabad, is the record of work carried out by her under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

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I, **Vanita Chaudhrani**, **16MCEN04**, give undertaking that the Major Project entitled "**Energy aware computing resource allocation using PSO in cloud**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Computer Science and Engineering (Networking Technologies)** of Institute of Technology, Nirma University, Ahmedabad, contains no material that has been awarded for any degree or diploma in any university or school in any territory to the best of my knowledge. It is the original work carried out by me and I give assurance that no attempt of plagiarism has been made.It contains no material that is previously published or written, except where reference has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

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Abstract

In cloud computing, there are large number of resources which are used like data centres, servers, CPUs, VMs, personal mobile devices and many more. It is difficult to manage these resources, for that resource management is used, so that proper use of resources is made.In this resource management, energy is one of the key parameters which is to be resolved. Resources in the cloud are using a large amount of energy and sometimes energy is wasted so these resources are needed to make energy efficient. Energy efficient resource management techniques help in cost reduction and improving the life of data centers. This paper discusses energy management techniques used in cloud and proposes particle swarm optimization (PSO) based VM allocation model to reduce energy consumption on hosts.

Abbreviations

IaaS	Infrastructure as a Service
PaaS	Platform as a Service
SaaS	Software as a Service
PSO	Particle Swarm Optimisation
DVFS	Dynamic Voltage and Frequency Scaling
CRAC	Computer Room Air Conditioning units
CSPs	Client Service Providers
PDUs	Power Distribution Units
HVAC	Heating Ventilation and Air-Conditioning
GUI	Graphical User Interface **RM**
VM	Virtual Machines
VMM	Virtual Machine Manager
MIPS	Multiple Instructions Per Second
IQR	Inter Quartile Range
MAD	Median Absolute Deviation
LR	Local Regression

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Chapter 1

Introduction

1.1 Introduction to cloud

Cloud computing is a model which enables convenient, ubiquitous, on-demand network access to a shared pool of various resources like networks, applications, storage, servers, etc which rapidly increases the CSP and user interaction. Cloud computing is one of the most immersing technologies now a days. It is very helpful to users for migration and computing the data without having an impact on performance of system.

It is a method of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer.

1.2 Components of cloud

Cloud has mainly these components:

- Fat client, Thin client and a mobile device are a part of Front end platform.
- Servers,storage and network are a part of back end platform.

Data Centres consist of these components:

- Computing equipments including network, storage and server components.
- Uninterrupted power supply components including PDUs, switch gears and generators.
- CRACs which is a cooling system.
- HVAC, pumps,chillers, direct expansion air handler units and cooling towers.

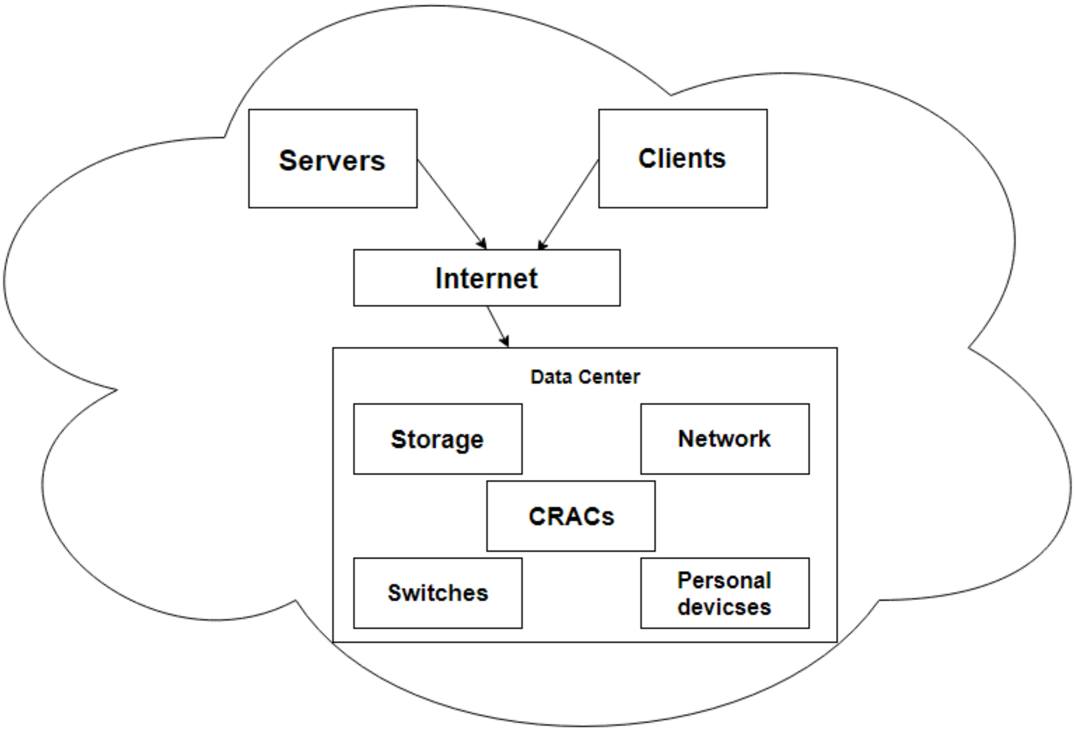

Figure 1.1: Components of cloud

- Secondary components like KVM Switches and laptops. [3]

1.3 Benefits of cloud computing

There are various benefits of cloud computing which are mentioned as follows:

- **Scalability:** It is defined as system's or product's capability for its proper functioning even if the workload is increased on it. The cloud gives the same efficiency even if the workload volume or size is increased.

- **Quality of Service:** QoS is defined as, a service which is provided to the users should be of a quality. In cloud, high QoS is maintained as the service provided to the users is fast and efficient.

- **Cost:** Cost is an important factor in every area now a days. Cloud delivers the services to the users at a very low rate. So, users are switching to use cloud in a large amount.

- **Energy Consumption:** Energy is one of the main benefits in cloud because, the services which are provided to the users in cloud is energy efficient. The back end infrastructure of cloud does include machines like servers and data centers which use a large amount of energy but there are already measures taken for a lesser energy consumption by them, so it makes cloud energy efficient.

- **Simpler user interface:** The GUI which is provided by cloud is easy to use and simple to understand. Any one can use services of cloud in a very convenient and an easy way.
- **Storage:** Biggest advantage of cloud is that it provides a large amount of storage to CSPs. They can store a large amount of data on their cloud, from where their users can access the data.
- **Globally used:** Cloud can be accessed from anywhere, anytime. A user using the services of cloud can access it any time whenever he wants. For example, AWS (Amazon Web Service).
- **Speed:** Cloud works at a high speed as it can store a large amount of data. The services which are also provided to the users are at a faster rate.
- **Performance:** Cloud usage gives the highest performance rather than the physical systems which are existing. We can define performance in various terms like storage, working and many more. Cloud services are not disappointing, neither to CSPs nor its users.
- **Reliability:**Cloud services are highly reliable. We can store our data securely on cloud.

1.4 Applications of cloud computing

Various uses of cloud computing are as follows:

- Development of various applications
- Creating various services for users
- Storage of various kinds of data
- Recovery of data is also possible

- Hosting various sites
- Video and audio streaming
- Software delivery on demand and many more..

1.5 Motivation of project

Efficient energy management is the main aspect for the project. There are various issues related to energy like low utilization of resources, peak load is high, large heat dissipation, decreased life time, large error occurrences, high electricity cost, large power is required for cooling system, large emission of gases which causes global warming and many more. Energy management is useful for solving these various energy problems. Energy management techniques and optimization techniques should be applied to various components which helps in reducing energy consumption. In such a way, energy efficiency of cloud will be increased.

Chapter 2

Literature Survey

2.1 Literature Survey

In this literature review, firstly cloud computing and energy management in cloud is studied. Survey papers of various energy management techniques have been studied. Later on resource management is studied. [4] Main concept is to make resource management energy efficient.Handling or Management of resources is a bit difficult and it consumes a large amount of energy, so energy efficient resource management is needed. In these survey papers, they have discussed about energy efficient resource management[5] [6]. Energy issues are reviewed, so that it is easy to analyze the solution of problem for a proper energy efficient resource management. [1] Various techniques for energy efficient resource management have been studied. Technique selection depends on the application and various other parameters[5] [6]. These techniques are further used on the basis of some metrics and parameters which are discussed in the next section. [4] With the help of parameters we can easily calculate energy consumed. These metrics are also useful in deciding which technique is to be used. [7]

Sr. No.	Paper	Energy management technique Used	Parameters Considered	Goal	Tool used
1	Tom Gurout et. al. [8]	DVFS	Sampling rate, Threshold value	To give an overview about simulators and to do energy consumption.	CloudSim
2	Fawaz Al-Hazemi [9]	DVFS	CPU Usage	To minimize power consumption, in IT serivce management	Tomcat webserver on CentOS
3	Selome Kostentinos et. al. [10]	DVFS	CPU frequency,Avg. arrival time, Avg. response time	For a dynamic resource management and energy management system	C++, Python
4	Thiago Kenji et. al. [11]	VM Consolidation	No.of hosts, No. of VMs	To allocate less VMs and that leads to lessen energy consumption	CloudSim
5	Dongyan Deng et. al. [12]	VM Consolidation	Avg. Utilization, Overloaded Host, No. of average hosts	For decreasing energy consumption and decreasing SLA violation	CloudSim

6	Priyanka Gupta et. al. [13]	Fuzzy MapReduce	Fuzzy membership function, processors, aggregate time, execution time, No. of jobs, Makespan	To improve energy aware multicore computing	MATLAB
7	Thomas Wirtz et. al. [14]	MapReduce	Workload Size, No. of workloads, Block Size which determines map reduce tasks	To analyze energy, determine energy requests of MapReduce jobs and a proper performance.	Hadoop
8	Seyed et. al. [15]	VM Allocation	Minimum Utilisation, Avg. Utilisation, Failure rate, Runtime	To allocate resources among competing jobs.	CloudSim
9	Eugen Feller et. al. [16]	VM Placement	Threshold Value, No. of cycles, probability, two constant parameters	To make an energy aware IaaS and for dynamic workload placement	CloudSim
10	Fahimeh Farahnakian et. al. [17]	VM Consolidation	CPU Capacity, Threshold Value, No. of VMs, No. of Hosts	To consume energy by doing dynamic VM Consolidation and maintaining QoS performance	CloudSim

11	P. Aruna et. al. [18]	PSO	No. of VMs, available hosts, MIPS, CPU Utilisation	To develop a power aware PSO for VM provisioning in Cloud	CloudSim
12	Li-Der Chou et. al. [19]	PSO, VM Allocation	No. of VMs, No. of data centers, simulated time, No. of particles, No. of iterations, Threshold Value	To develop a resource allocation mechanism, reducing power consumption and managing costs	CloudSim
13	Mohammad Alaul et. al. [20]	VM Consolidation	No. of VMs, CPU Usage, Threshold Value	To do VM migration along with energy management	CloudSim
14	Dabiah Ahmed et. al. [21]	VM Consolidation	MIPS, Threshold Value, No. of VMs, Storage, RAM	To do energy management and QoS parameter consolidation	CloudSim
15	Allen D. et. al. [22]	VM Consolidation	CPU Usage, Threshold value, No. of VMs, No. of Hosts	To multipass VM placement and for less violation and less energy consumption	CloudSim

Table 2.1: Literature Review of the existing methods

Chapter 3

Energy efficient resource management

3.1 Energy management in cloud

- Along with the reliability of cloud computing services,energy consumption by the underlying complex infrastructure providing cloud services is also a big concern for cloud service providers.

- As increasing the reliability of cloud services makes it profitable by attracting more users or clients, decrease in the energy consumption will make it even more profitable by reducing the operational expenses of underlying infrastructure in terms of electricity bills.

- Besides the construction of data centers by adding temperature monitoring equipment,optimized air vent-tiles, putting plates to block cold air passing through the racks,designing of optimized software systems is important for the proper utilisation of resources of cloud infrastructure to increase the energy efficiency. [23]

- The energy consumption is dependent on the resource management system as well as the physical resources and applications deployed on the system. This interaction of various levels of computing systems and energy consumption is shown in Figure 1. [24]

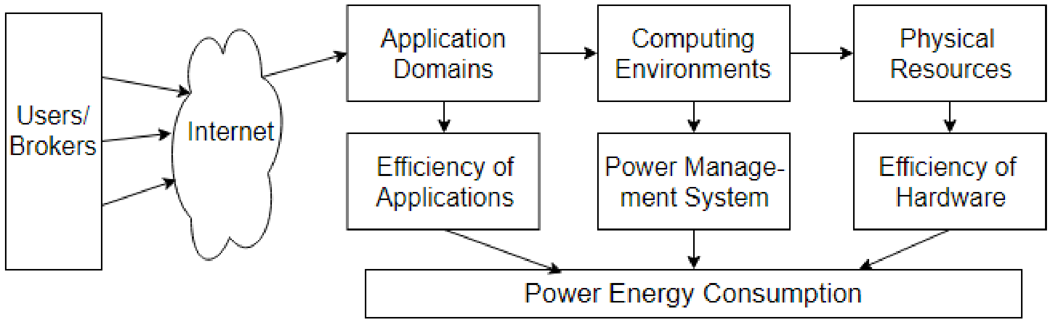

Figure 3.1: Energy management in cloud [1]

3.2 Problems of energy inefficiency in cloud

Main problems of energy inefficiency are:

- Low average utilisation of the resources.
- High peak load and large fault tolerance.
- Large heat dissipation.
- Decreased lifetime and high error proneness.
- Large power for cooling system.
- High Electricity cost.
- Minimization of the peak power which is required for complete system.
- Large emission of carbon dioxide gases resulting in global warming. [1]

3.3 Resource Management:

- RM is a process which deals with the resources working or involved in the system. Virtualization techniques are utilised for on-demand and flexible resource provisioning.
- For doing this, for every task which is received, a new VM is created or the task is kept on the existing VM. After the task is done, all resources become a part of the resource pool.
- Resource Management does the allocation of system resources like VMs, network components, CPU, storage, memory and other devices. [4]

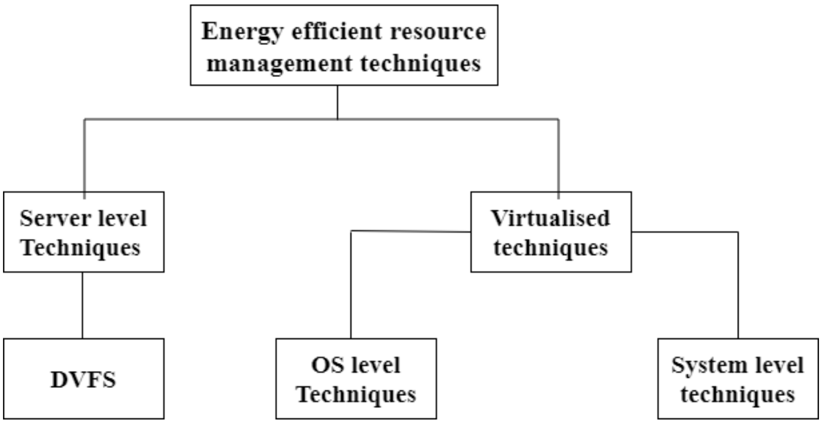

Figure 3.2: Energy efficient resource management techniques

3.4 Energy efficient resource management

- By efficient resource management, handling requests is easy, handling of any service within the QoS constraints will increase the level of resource utilisation.
- Improved resource utilisation helps in decreasing energy demand.So, resource utilisation and energy consumed are closely related.
- The resources when they are over utilised or under utilised demand more energy. So, proper utilisation of resources improves energy efficiency.
- When the resources are under utilised, the resources are not being used, they are just idle so unnecessarily energy is wasted.
- Over utilisation is excess use of resource which increases the energy use and also makes the system inefficient. [5] [6]

3.5 Techniques for energy efficient resource management

There are various energy efficient resource management techniques which are divided in two types:

- Server level techniques
- Virtualized level techniques

Virtualized level techniques are further classified into:

- OS level techniques
- System level techniques. [6]

3.5.1 Server level techniques

Main technique under this part is:

DVFS (Dynamic Voltage Frequency Scaling)

- It is a technique which is used for both memory and CPU and it improves the power consumption of both elements.
- It helps in enabling the dynamic power management and it is done by varying the voltage and frequencies of the processor and memory.
- Using this technique, CPU frequency can be changed according to the workload.
- This technique can be implemented on CPU and memory both.

3.5.2 Virtualized level techniques

- Virtualization is a technique in which the efficiency of hardware utilisation is improved by migration, resource sharing and consolidation of workloads.
- Virtualization is the creation of a virtual or a a passive form of something, such as a storage device or server or a desktop or any operating system.
- It is a technique where a single instance of multiple resource is created.

OS level techniques

On OS level, there is a so called container which shares the same kernel with the host and is defined as light weight virtual environment that provides a layer of isolation between workloads without the overhead of hypervisor based virtualization.

Energy management techniques applied for OS level virtualization are:

- Container placement
- Service Consolidation

System level techniques

Previously, a specific environment was simulated which considers memory, processor and I/O device. After that, idea was encouraged by developing efficient simulators for providing copies of a server on itself. These simulated environments(copies) are known as VMs and the simulator is VMM also known as hypervisor. Such method is said to be as system level virtualization.

There are various system level techniques for energy efficiency which are:

- VM Consolidation
- Resources Overbooking
- VM Placement
- VM Sizing
- DVFS
- Resource Throttling

VM Consolidation

This technique does consolidation which is an effective way to minimize energy consumption of cloud data centres. In this techniques, VMs are to be migrated when the host is overloaded. Migration should be done at a perfect time so that quality of service is maintained. Once a VM is migrated, on which other VM it should be migrated, that should be taken in consideration. Later, the workload is migrated to the under utilised hosts so that proper resources are maintained and utilised. It refers to when data storage or server resources are shared among multiple uses and accessed by multiple applications. It makes efficient use of resources and prevent servers and storage from being utilised.

Resources Overbooking

It is an admission control technique which improves utilisation of resources in cloud data centres. In this, users should estimate what size of VM they need and accordingly they should select so that resource shortage is avoided. Using this technique, users decide the resources on their own which they want to use. Overbooking strategies depends on the load balancing techniques so that proper resource utilisation is done and performance is improved and SLAs are not violated. When the data centres are highly overloaded than these techniques are not preferred.

VM Placement

Among various resource management techniques, initial placement of VMs plays an important role in improving the overall performance of the data centres and consumption of the energy by various resources. With the help of VM placement, system overhead is improved by reducing the required number of migrations. VM placement also helps in managing geographical infrastructure to achieve scalability and which also provide cloud cluster and node selection mechanisms to improve energy efficiency. VM placement is done in two ways which are:

- Centralized
- Hierarchical

Centralized VM placement algorithm was proposed for reducing power consumption. There is an information system which has all the updated information of cloud, host utilisation which helps in resource optimisation and central decision making.
When there is a multi-site data centre, hierarchical approach is used. In this approach there are two layers. The upper layer manages the VM requests and lower layer places VM to hosts in each site.

VM Sizing

There are two approaches in this technique which are:
1. Static VM Sizing
2. Dynamic VM Sizing

In Static VM sizing, there are two approaches, in first approach, VMs are assigned according to the fixed sizes of their hosts and consolidated to less number of servers without the change of configuration. In second approach, according to the workload, configuration is managed.
In Dynamic sizing, VM's configuration is adjusted to its workload in run time.

DVFS

In this approach, energy efficient VM scheduling is done on the DVFS enabled compute clusters. Using this method, jobs will be assigned to the predefined VMs, and VMs shut down when the jobs are finished. The scheduling approach is operated considering two approaches:

- This algorithm optimizes the processor power dissipating by running CPU at lower frequencies.
- VMs are scheduled on CPUs with low voltage. Lastly, it can change the voltage and frequency of CPU or host according to the load.

Resource Throttling

Resource Throttling means resource controlling. When a user is using large number of resources from any of services of cloud like IaaS, PaaS, SaaS then you can control/throttle the behavior of a user. Resources should be scaled accordingly. It should be according to the demand o resources, workload, etc. User can also be charged so that a user uses proper amount of resources and resources are not wasted. In cloud, network bandwidth, CPU usage, storage, I/O operation and more resources can be throttled. [5]

3.6 PSO: An optimization technique used for Energy Management

3.6.1 Basic PSO

- Inspired by social behavior and movement of insects, birds, etc.
- It is a method where mathematical formula is applied over velocity and position of the particle.
- Local best position helps in depicting the movement of particle.
- This helps in finding the next position and for updating position of the particle.
- In PSO, the particles are having fitness values which are calculated through fitness function.

PSO Algorithm:

- **Initialisation:**
  - Set constants k_{max}, c_1, c_2.

- Randomly initialise particles position and velocity.

- **Optimisation:**
  - **First step:** Evaluate function values f_k^i using design space coordinates x_k^i.
  - **Second step:** If $f_k^i <= f_{best}^i$ then,$f_{best}^i = f_k^i$, $p_k^i = x_k^i$
  - **Third Step:** If $f_k^i <= f_{best}^g$ then,$f_{best}^g = f_k^i$, $p_k^g = x_k^i$
  - **Forth Step:** If terminating condition is satisfied, go to Third Step
  - **Fifth Step:** Update particle velocities by the following formula:

$$v_{k+1}^i = v_k^i + c_1 r_1 (p_k^i - x_k^i) + c_2 r_2 (p_k^g - x_k^i) \quad (3.1)$$

  - **Sixth Step:** Update particle position by the following formula:

$$x_{k+1}^i = x_k^i + v_{k+1}^i \quad (3.2)$$

  - **Seventh Step:** Increment k.
  - Go to First step.

- **Terminate** [25]

where,

x_k^i - Particle Position

v_k^i - Particle Velocity

p_k^i - Best "remembered" individual particle position.

p_k^g - Best global value.

c_1, c_2 - Cognitive and social parameters.

r_1, r_2 - Random numbers between 0 and 1.

3.6.2 Energy aware PSO

In this section, PSO is explained in terms of this project in cloud. Energy aware PSO helps in maintaining energy of cloud. It is also helpful in VM allocation. With the help of this, VMs are allocated on hosts. PSO is a technique which does a best global search, here in this environment, it helps us to find the best energy value of host.

Terminology of PSO:

- **Particle:** Particle in PSO is referred to as a bird which is in search of food. Every particle in PSO is referred by its position and velocity. There is a best local value and best global value of particle. In this project, a host is considered as a particle.

- **Position of Particle:** This describes the particle's current state. In this project, it will determine Boolean values either 0 or 1. This describes, whether a VM will be allocated to a host or not.

- **Velocity of particle:** Calculation is done on basis of dependency of position of particle. In this project, term energy is considered instead of velocity, which represents the energy of the particle i.e the host.

- **Total size of population:** This indicates total population size of particles. In this project, it describes total number of hosts.

- **Best Local values:** This represents the particle's best value. In this project, best local value is the best value of a single host among all the iterations.

- **Best Global value:** This represents the best value of any particle among all the particles. Here, it represent the best value of a host among all the other hosts.

Chapter 4

Proposed Architecture

4.1 Proposed Architecture:

- In this architecture, there are VM requests coming from the user and those requests are handled by VM Request Handler.
- These requests are allocated to hosts by this request handler and it is a random allocation.
- There is an another module which monitors the energy of every host. This module also helps in detecting the overutilised host. Detection of overutilised host is mentioned in section 5.2.
- Optimisation of energy is done by PSO method and after that gain VMs are allocated to the hosts as per the energy constraints.

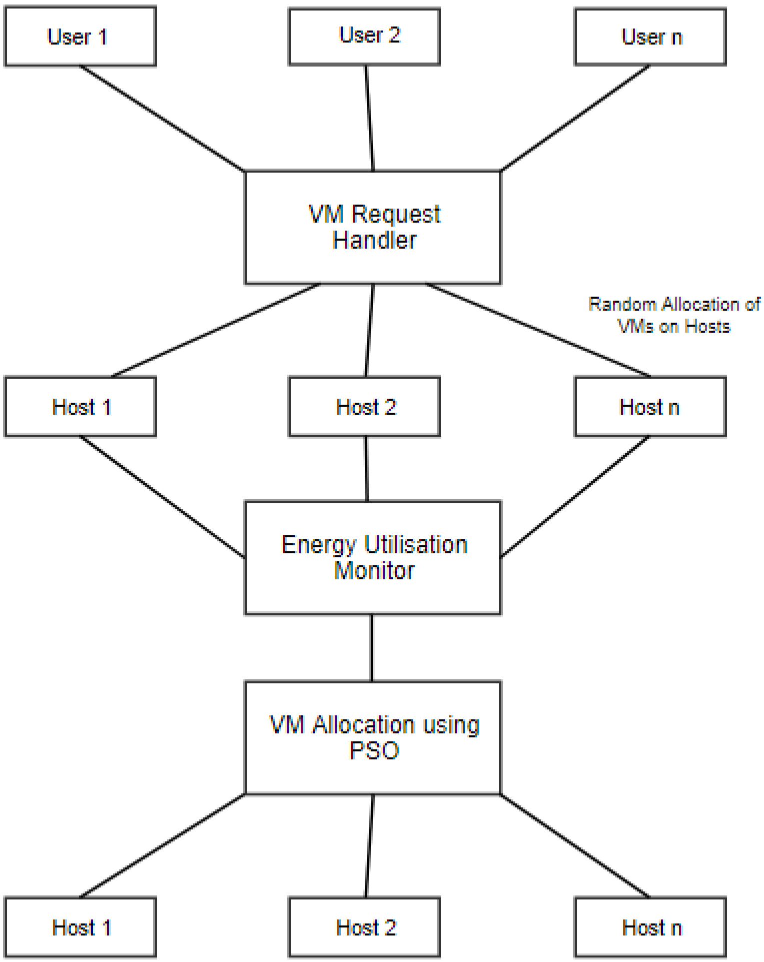

Figure 4.1: Proposed Architecture

4.2 Overloaded host detection

There are VMs allocated to the hosts. Large number of requests are constantly coming on VMs. If there are large number of VMs on any host, that can create energy problem. High energy consumption is done by that particular host. So to prevent that energy management technique VM Consolidation is applied. While applying such technique, overloaded host is to be detected. Once overloaded host is detected the VM migration is done on the host where there are less number of VMs or requests. This can prevent high energy consumption and the idle hosts which are constantly consuming energy will consume energy in a better manner. There are various techniques which helps in detecting overutilised host which are mentioned below.

4.2.1 IQR method

IQR(Inter Quartile Range) method:

- Sort data set in increasing order.
- Find median for this ordered set i.e Q_2
- Divide this data set into two parts.
- Median is to be found out of these parts and they are represented as Q_1 and Q_3
- Find the inter quartile range by the formula:

$$IQR = Q_3 - Q_1 \tag{4.1}$$

Data set- Host Utilisation History

Q_1 - Least power utilised

Q_3 - Highest power utilised [26]

4.2.2 MAD method

MAD(Median Absolute Deviation) method:

- MAD is defined as the median of the absolute deviations from the datas median.
- It is calculated by the following formula:

$$MAD = median(|Y_i - median(Y_i)|) \tag{4.2}$$

Y_i - It is the host utilisation set. [26]

4.2.3 LR method

LR(Local Regression) method:

- It is based on Loess method.
- It is calculated on the basis of Tricube weight function.

- Tricube function is represented as follows:

$$T(u) = (1 - u^3)^3 \tag{4.3}$$

- This is a weighted function which is represented further as:

$$w_i(x) = T\left(\frac{\Delta_i(x_k)}{\Delta_1(x_k)}\right) \tag{4.4}$$

$$w_i(x) = \left(1 - \left(\frac{x_k - x_i}{x_k - x_1}\right)^3\right)^3 \tag{4.5}$$

  where,

  x_k- It is the last host utilisation.

  x_i - Current host utilisation.

  x_1 - First host utilisation. [26]

4.3 Graphs

- In this section, comparison between these methods is shown.
- Graph represents the execution time by various number of VMs.
- Here VMs are varied and the number of hosts remains the same i.e 50.
- Execution time is compared when these methods are used.
- Least execution time is there when LRMc method is used for overloaded host detection
- So LRMc technique is used for overloaded host detection.
- Graph is represented according to the data mentioned in Fig. 5.2

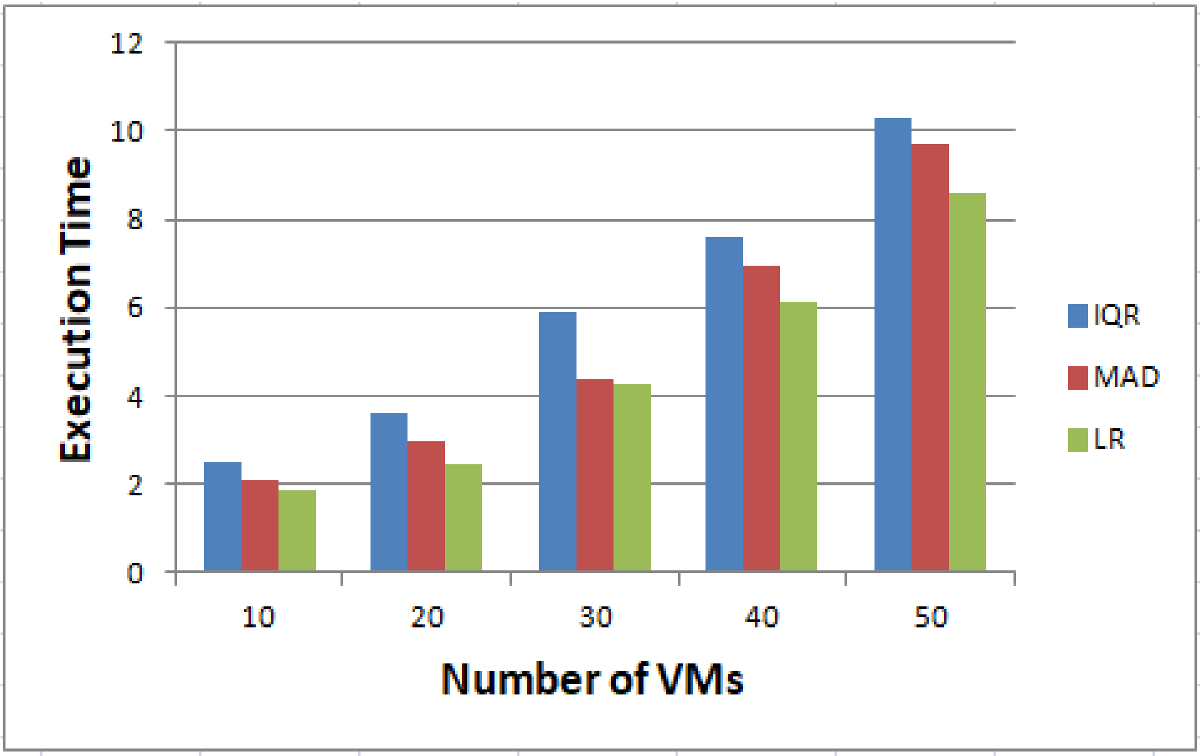

Figure 4.2: Comparison between IQRMc, MADMc, LRMc

Chapter 5

Proposed Algorithm

5.1 Energy aware VM Allocation using PSO

- For VM Allocation, VM Migration is to be done.
- Overloaded host is to be detected for doing VM migration.
- Overloaded host detection is done by Local Regression method.
- Once overloaded host is detected, VMs are to be migrated and those VMs are to be allocated on other hosts.
- VM allocation is to be done by PSO Algorithm.

5.2 Flowchart of the proposed algorithm

This Figure depicts the flow of algorithm.

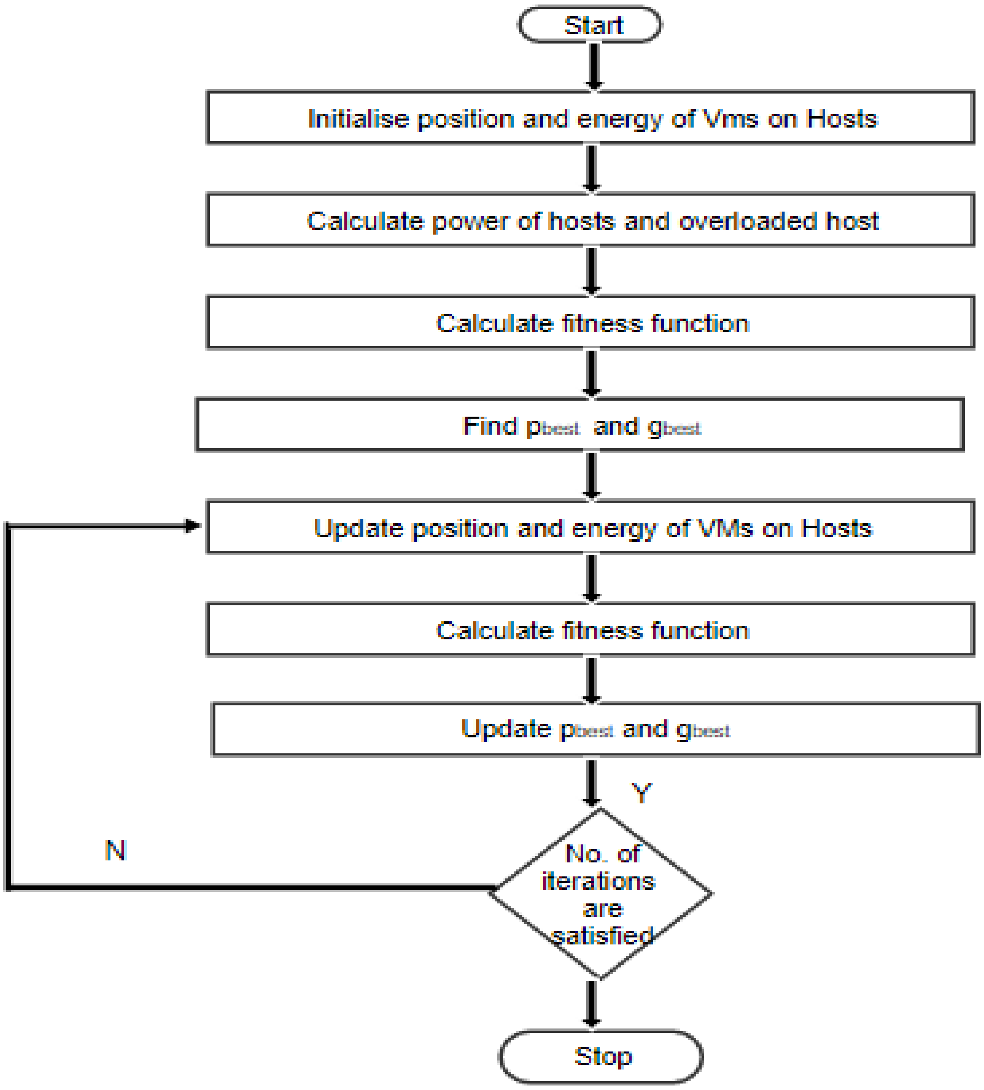

Figure 5.1: Flowchart of the proposed algorithm

5.3 Proposed Algorithm

- This algorithm optimises the energy of the overloaded hosts.
- In overloaded host detection algorithm, it is checked that whether the host is overloaded or not.
- If the host is not overloaded, VMs are allocated on the hosts.
- VM allocation on hosts is subjected to constraints:

$$x_{ij} = \{1 where No.of requests > No.of allocations on VMs\} \; x_{ij} = \{0 otherwise\} \tag{5.1}$$

- Once VM allocation is done, power is calculated of every host and overloaded host.
- The power of every host is stored in a list which helps in calculation of fitness function.
- Once position and energy of VM on host is obtained, PSO is applied to them.
- From all these values p_{best} and g_{best} are calculated.
- p_{best} is the best value of energy of a single host in comparison to other VMs while g_{best} is the best value of energy of hosts in comparison to all the other hosts,
- This is done till the total number of hosts.
- At last, we get the VM allocation with the least energy consumption.

Algorithm 1 Overloaded Host Detection

Input:Number of Hosts,Number of VMs

Step 1: Find the overload Host

if (host<= $1 - u^3)^3$ **then**

VMs allocate to that host

else

The host is overloaded host

end if

Step 2: Calculate power of host using:

$$P_{host} = P_1 + (\frac{P_2 - P_1}{10}) * (utilisation_2 - utilisation_1)$$

Step 3: The power of all the hosts are stored in a List

Step 4: Exit

Algorithm 2 Energy aware PSO

Step 1: get x_{ij}, v_{ij}, these values are obtained from Overloaded Host Detection

Step 2: fetch P_{host}

Step 3: Calculate P_j using the following fitness function:

$$P_j = (P_{overloadedhost} - P_{idle}) * CPU_{utilisation} + P_i$$

Step 4: Select p_{best} and g_{best}

Step 5: Repeat {It is to be repeated upto n number of hosts}

Step 6: Updation of x_{ij},v_{ij} using equations (1) and (2)

Step 7: Repeat **Step 3**

Step 8: Update values of p_{best} and g_{best}.

Step 9:exit {Stopping condition is till the total number of hosts}

Output: Power on host having the lowest energy consumption.

Chapter 6

Simulator used for calculating energy efficiency

6.1 CloudSim

- CloudSim is a generalized and extensible simulation framework which helps in modelling and simulation of application performance.
- Developers can do changes according to their requirements and they do not have to get worried about services and infrastructures of cloud.
- CloudSim helps in providing system and behavioural modelling of components of cloud. It helps in investigating dynamic, scalable and distributed environments.
- CloudSim is used for developing a large data center with any number of VMs(Virtual Machines), any type of broker policy and every customisation is done according to the developer's requirement.
- One interesting feature of this framework is a federated policy where multiple external and internal clouds are mixed up so that business needs are satisfied.[2]

Advantages of CloudSim:

- Defining Configurations are easy and flexible.
- It is easy to use and customise.
- Cost benefits are high.

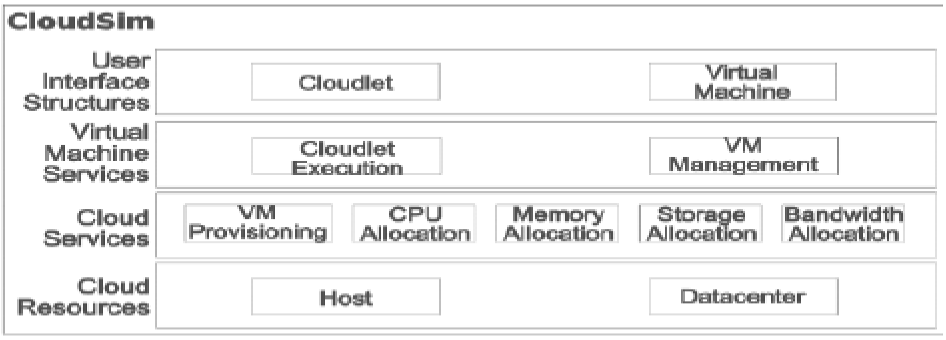

Figure 6.1: CloudSim Architecture [2]

CloudSim architecture:

- Fig. 4.1 represents the architecture of CloudSim.
- In this architecture, there are 4 layers.
- The lowest layer represents the resources provided by the cloud like data centres and hosts.
- Then comes the third layer which represents the services provided by the cloud like VM provisioning, VM allocation, Power Management, CPU allocation and many more.
- Second layer represents VM services like VM management and cloudlets execution.
- First layer represents the services provided to the user like user interface to execute their tasks.

Chapter 7

Implementation

7.0.1 Simulation Parameters

Simulation parameters used in this project are as mentioned below:

- **Number of VMs:**10
- **Number of Hosts:**10
- **Iterations:**100(Implemeted at a range of 10)
- **VM specifications:**
  - **VM MIPS:** 2500
  - **VM Bandwidth:**100 Mbps
  - **VM Size:**2.5 GB
- **Host specifications:**
  - **Host MIPS:**2660
  - **Host Bandwidth:**1 Gbps
  - **Host Storage:**10 GB

7.0.2 Results

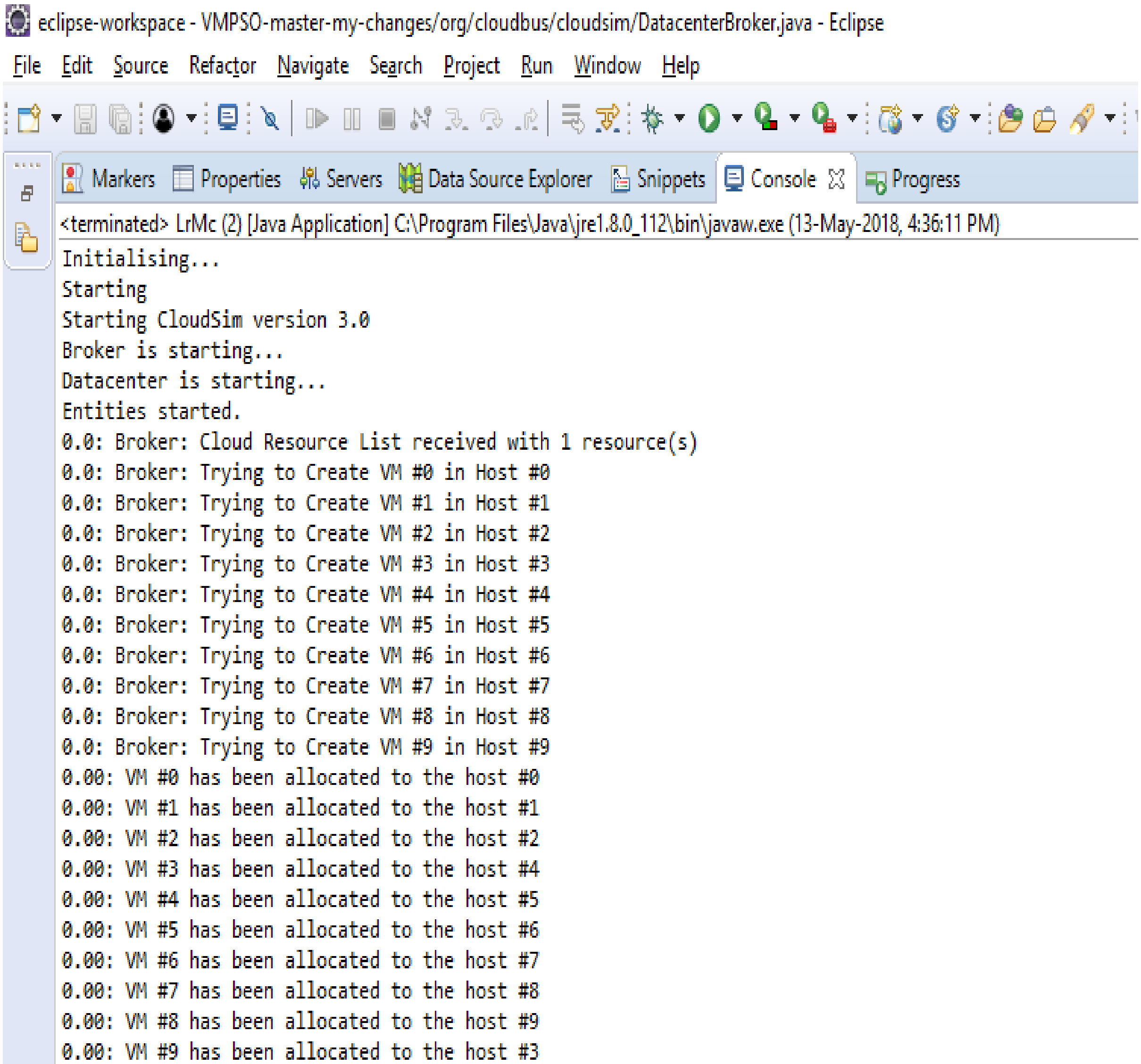

Figure 7.1: Initial allocation of VMs on hosts

Fig 7.1 depicts the initial allocation of VMs on hosts. In this figure, broker is trying to create VMs on hosts. In later part of the figure,VMs are allocated on hosts. This is a one to one allocation. Last VM is allocated to the overutilised host, which is mentioned in the next figure 7.2.

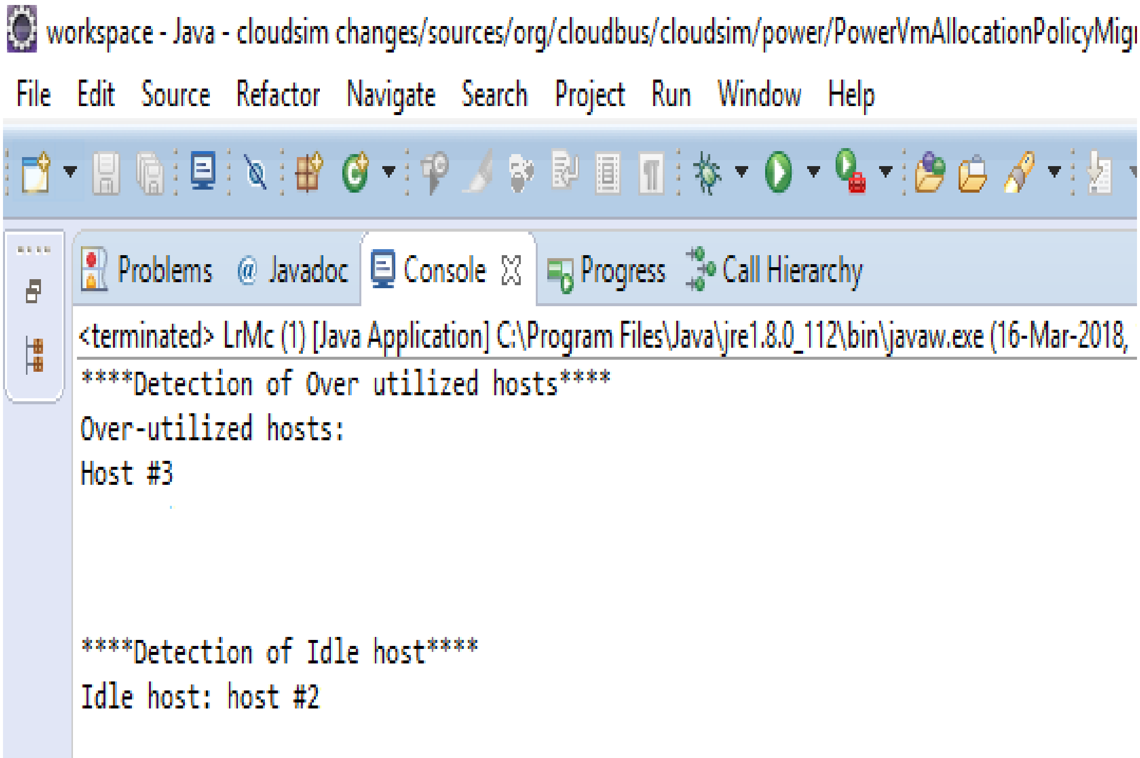

Figure 7.2: Detection of over utilized hosts

Fig. 7.2 depicts the output of over utilized host. According to the algorithm 1, we detect the over utilized host. In algorithm 1, we are detecting over utilized host on the basis of local regression method. This method is implemented in cloudsim, which helps in detection of over utilized host.

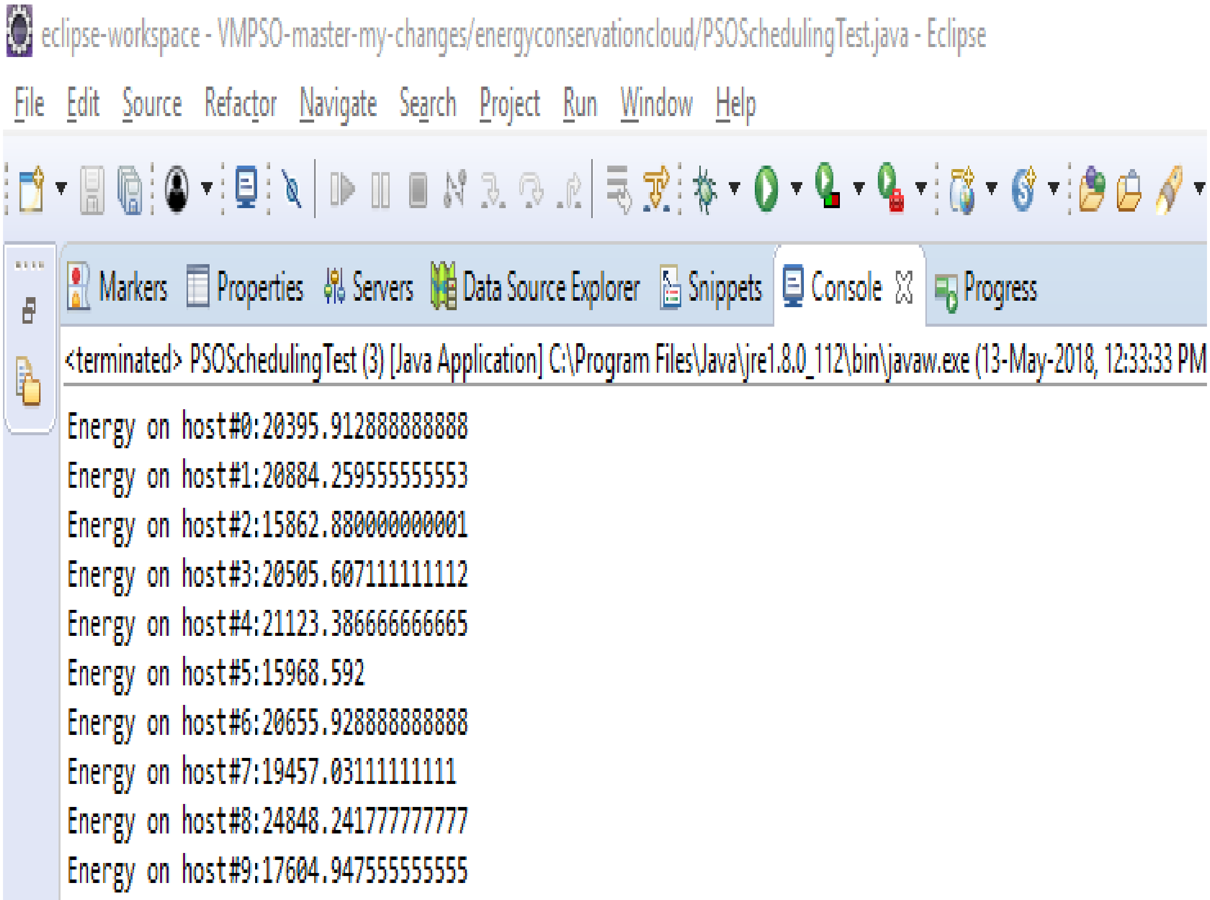

Figure 7.3: Energy on all hosts initially

Fig. 7.3 depicts the energy on all the hosts. Energy of all the hosts is calculated in Algorithm 1(Overloaded Host Detection). These values of energy helps in calculating energy of hosts in various other iterations. These values of energy are in Watt per hour(Wh).

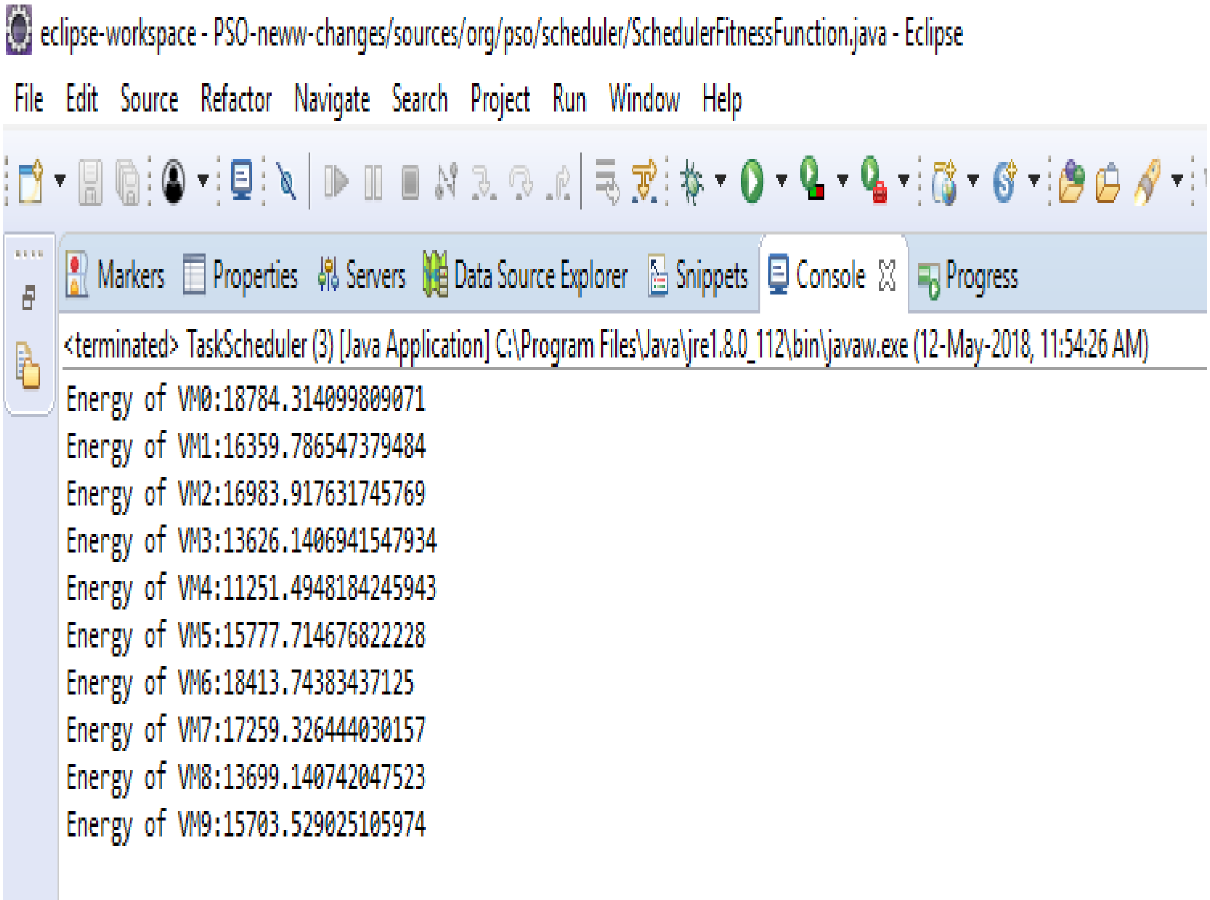

Figure 7.4: Energy on all VMs

Fig. 7.4 depicts the energy on all the VMs. Energy on all the VMs is calculated in cloudsim. These values of energy are in Watt per hour(Wh). These values are same throughout all the iterations.

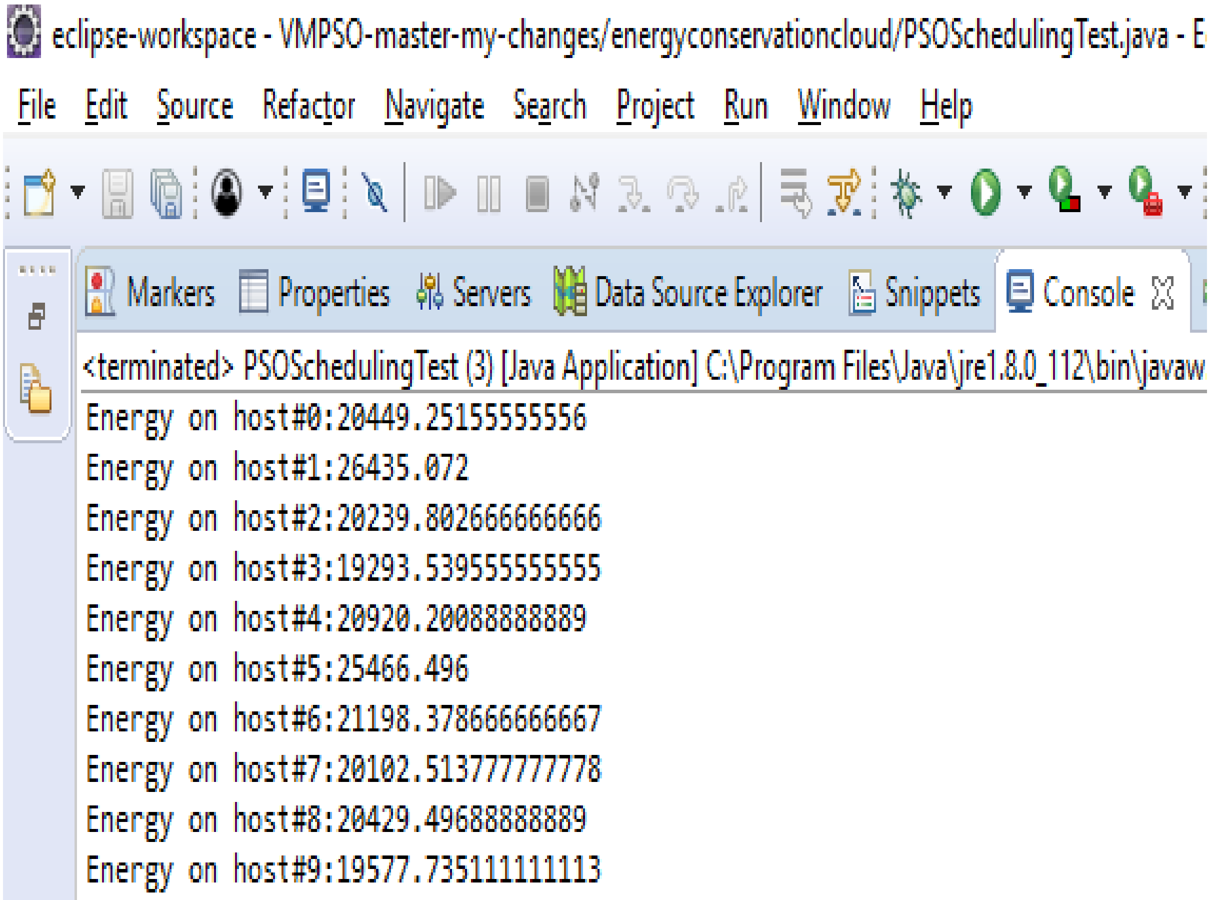

Figure 7.5: Energy on host after Iteration-1

Fig. 7.5 depicts the energy on all hosts after iteration 1. These values of energy is calculated with the help of formula mentioned in Algorithm 2(Energy aware PSO).

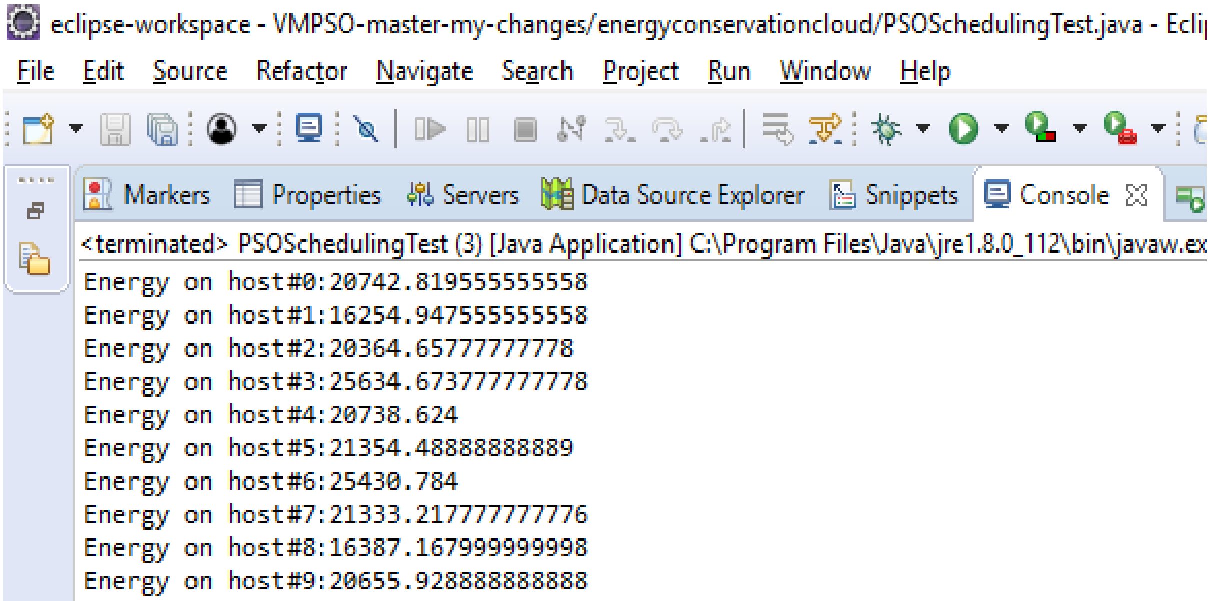

Figure 7.6: Energy on host after Iteration-2

Fig. 7.6 depicts the energy on all hosts after iteration 2.

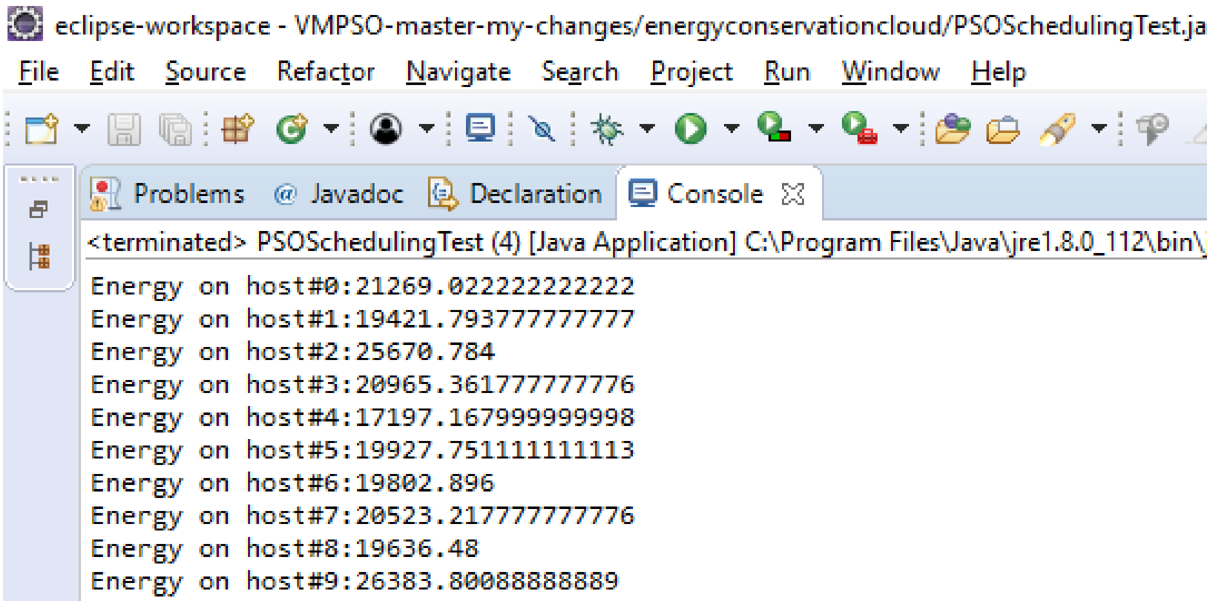

Figure 7.7: Energy on host after Iteration-10

Fig. 7.7 depicts the energy on all hosts after iteration 10.

Iteration	**Host 0**	**Host 1**	**Host 2**	**Host 3**	**Host 4**	**Host 5**	**Host 6**	**Host 7**	**Host 8**	**Host 9**
1	20449.2155	26435.07255	20239.80267	19293.53955	20920.20099	25466.496	21198.3787	20102.51378	20429.4969	19577.73513
2	20742.81958	19254.94766	20364.65788	25634.67378	16920.20099	21354.48889	25430.784	21333.2178	19387.16799	20655.92888
3	21269.02244	19421.79377	25670.78444	20523.21778	18636.48778	26383.80899	20004.16711	18708.79088	17687.16799	17035.82044
4	17197.18322	19927.75113	19802.84577	18917.48977	18616.48671	24709.58933	24338.79285	18862.60622	19635.024	17668.76088
5	18348.77432	18032.19325	17325.69778	18413.32466	16095.84759	21269.02222	25670.78445	19328.61343	18325.91332	20482.18342
6	17846.94641	25281.34821	21248.12688	19268.24899	17348.21568	19031.73458	28682.60622	20421.16823	20348.86688	18635.24862
7	18462.74821	20148.18432	20934.72344	21325.18667	18143.48639	21832.63482	20423.82667	19385.68244	17932.81422	19823.75833
8	19800.41966	19602.87111	18042.86389	20425.83256	19251.42441	20118.18244	21863.20432	21369.42488	18148.48367	17432.9245
9	20325.41232	19816.21886	16940.58311	18937.21466	16413.38708	24132.92346	19246.13428	18578.63488	18943.77455	18775.21455
10	21269.02222	19421.79377	25670.784	20965.36177	17197.16799	19927.75113	19802.896	20523.21776	19636.48	26383.80899
P best	**17197.1832**	**18032.1932**	**16940.5831**	**18413.3246**	**16095.8475**	**19031.7345**	**19246.1342**	**18578.6348**	**17687.1679**	**17035.8204**

Table 7.1: Table containing all values of energy of all hosts

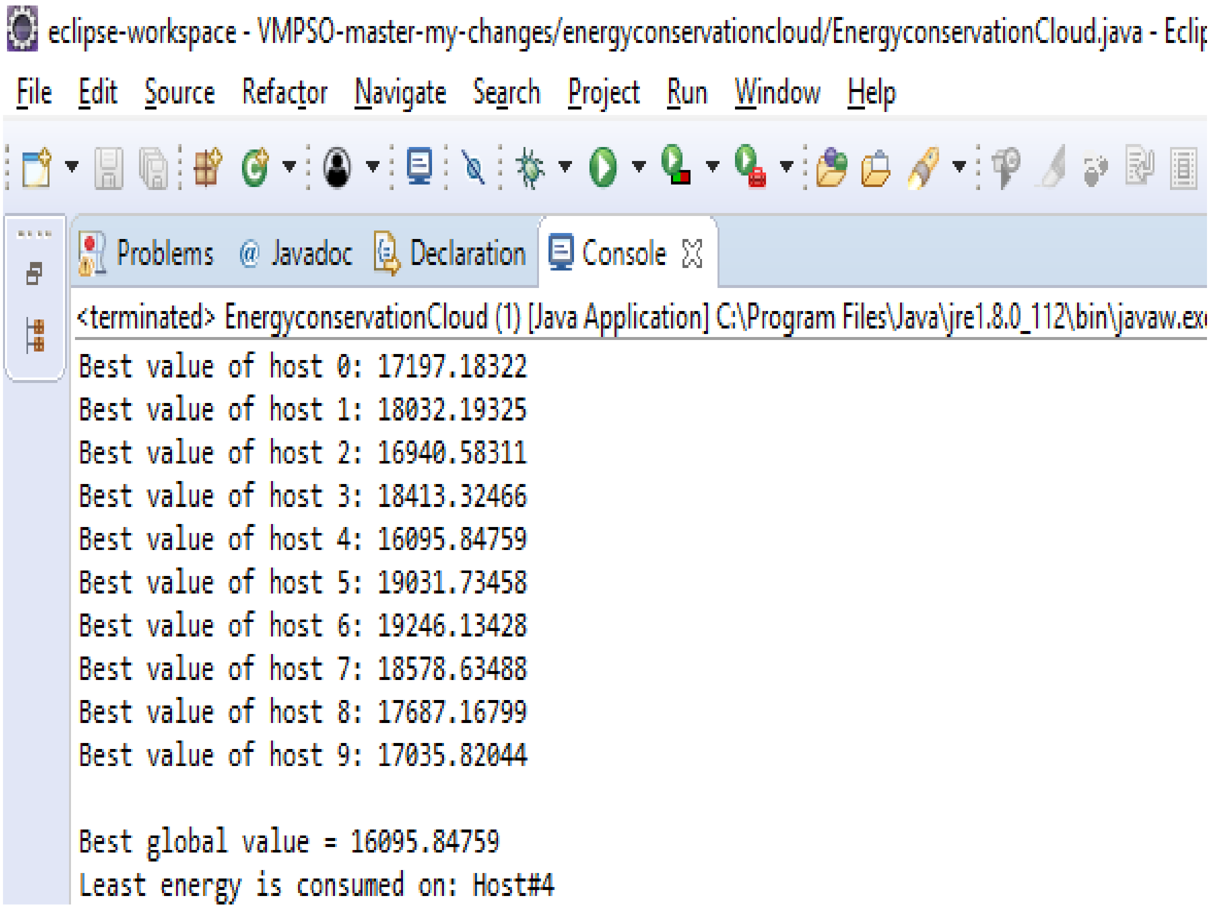

Figure 7.8: Host with the best energy consumption

Fig. 7.8 depicts the best values(Pbest) of all the hosts. These values are obtained by using PSO. These values are best local values of all hosts. From these best local values, we get a single best value, i.e Global best value. This value represent the host which is having the least energy.

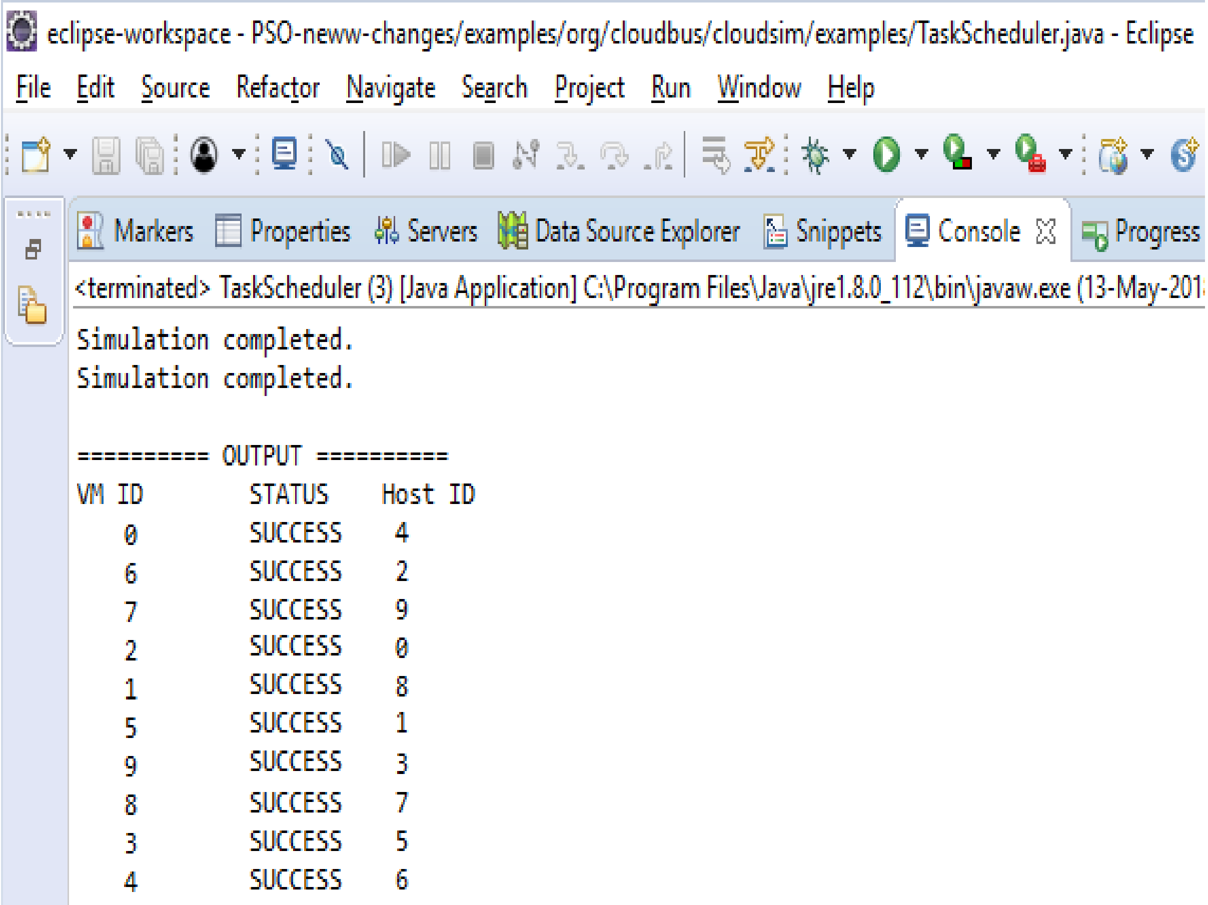

Figure 7.9: Final allocation

Fig. 7.9 depicts the final allocation of VMs on the hosts. This allocation is done on the basis of comparision of energy of VMs and hosts.

7.0.3 Graphs

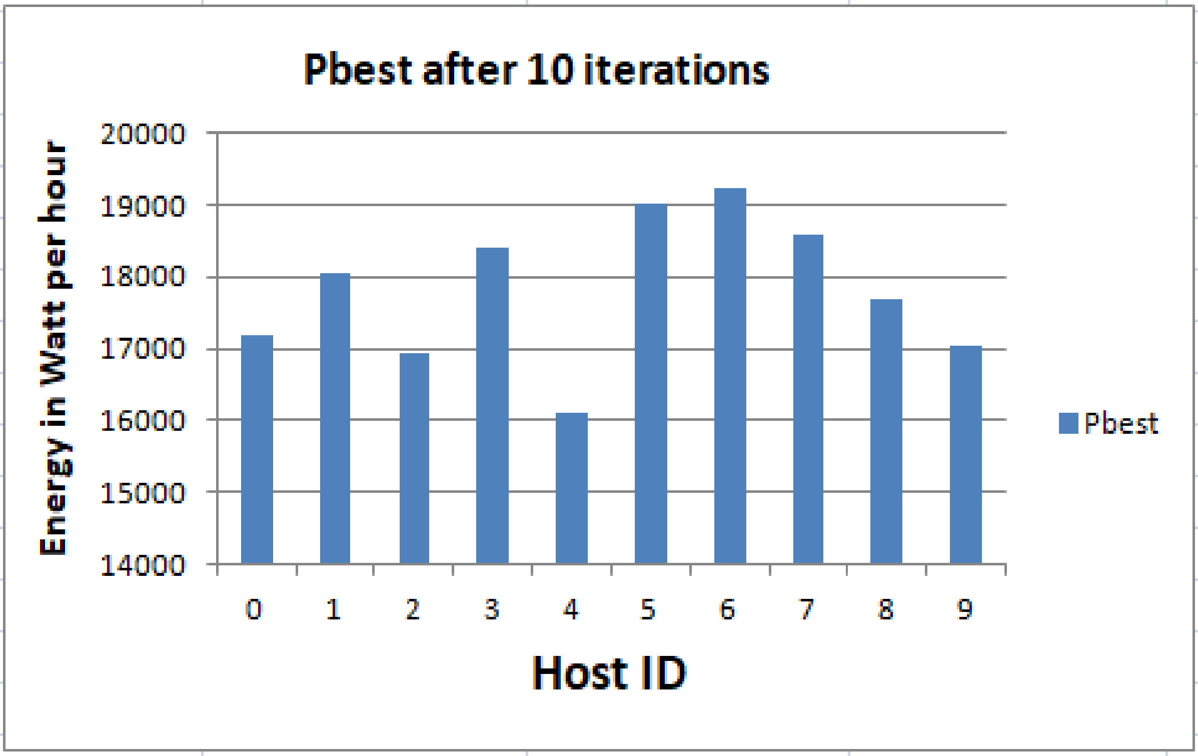

Figure 7.10: Graph representing the best host after 10 iterations

Fig. 7.10 depicts the graph which is representing best local values of energy of each host after 10 iterations. The host 4 is having the least energy consumption, so that is the best global value of energy.

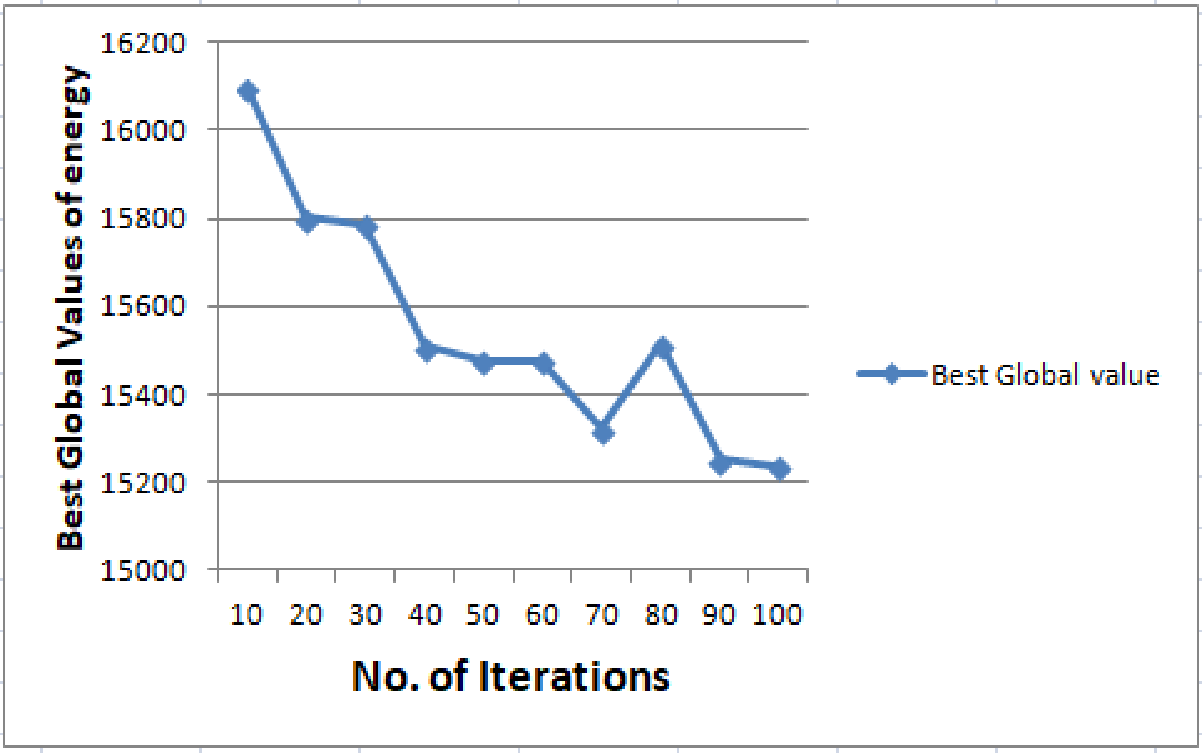

Figure 7.11: Best global values after 100 iterations(Range-10)

Fig. 7.11 depicts the best global values of hosts after various iterations. These iterations have been implemented in cloudsim after range of 10 iterations. As the iterations increase, we get better values of energy.

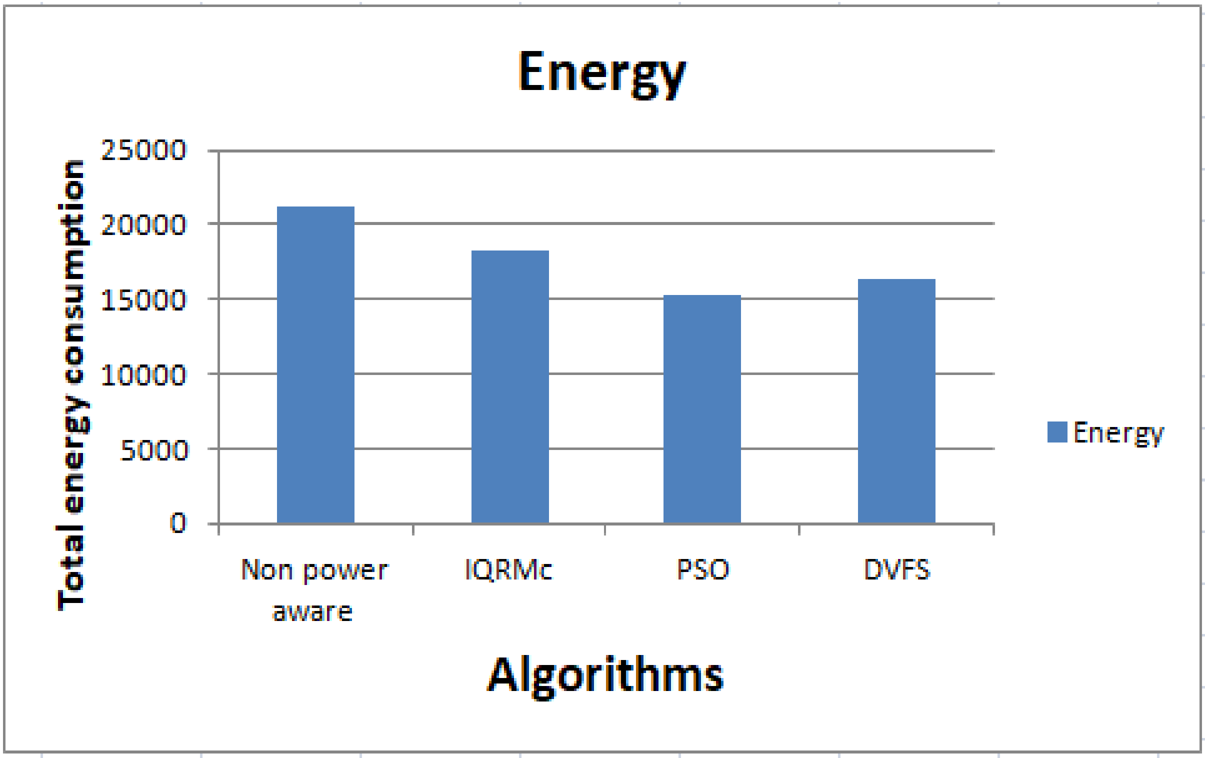

Figure 7.12: Comparision of various algorithms

Fig. 7.12 depicts the comparison of various algorithms in terms of energy. These algorithms DVFS,IQRMc, Non power aware are implemented in cloudsim and compared with energy aware PSO. The results show that by using energy aware PSO, least energy is consumed by hosts.

Chapter 8

Conclusion and Future Work

8.1 Conclusion

From graph, Fig. 7.12, it is concluded that least energy consumption is done by energy aware PSO algorithm. In this project, overloaded hosts are detected and least energy consumption on hosts is calculated. Overloaded hosts are detected by Local Regression method. Using these algorithms and techniques, finally VMs are allocated to the hosts on the basis of energy. This project is implemented in cloudsim for proper optimisation of energy.

8.2 Future Work

In future, VM migration is to be done on hosts. If proper migration is carried out alongwith allocation, then energy can be consumed properly by the hosts as well as VMs.

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