



## AN IMPLEMENTATION OF CARBON EFFICIENT VM PLACEMENT AND MIGRATION TECHNIQUE IN CLOUD ENVIRONMENT

Sakshi Grover <sup>(1)</sup>, Mr. Navtej Singh Ghumman <sup>(2)</sup>

<sup>(1)</sup> Research Scholar, Department of Computer Science & Engineering, SBSSTC, Ferozepur, Punjab.  
sakshi26grover@gmail.com

<sup>(2)</sup> Assistant Professor, Department of Computer Science & Engineering, SBSSTC, Ferozepur, Punjab.  
navtejghumman@yahoo.com

### ABSTRACT

Electricity consumption is set to rise 76% from 2007 to 2030 and datacenters are the main contributors of an important portion of this increase, emphasizes the importance of reducing energy consumption in clouds. Increase in the level of carbon dioxide in our ecosystem is another consequence of this increasing amount of energy consumption by the datacenters. According to Gartner, the Information and communication industry produces 2% of global carbon dioxide emission [10]. Hence, there is a great requirement of making use of more environmentally friendly computing called "Green Cloud Computing" to minimize operational and energy consumption costs and also to reduce the environmental impact. In this paper, we have implemented the carbon efficient VM placement and migration technique in cloud simulator.

### Keywords

Cloud Computing, Power Data Center, Carbon Footprint, Load Balancing, Virtual Machine, Energy, Data Center Broker.

### INTRODUCTION

Cloud Computing is the biggest technology advancement now a days. It has taken computing in initial to the next level. Cloud computing provides the information technology as a service. Cloud computing uses the internet and the central remote servers to support different data and applications. It is an internet based technology. It allows the users to find their personal files at any computer with internet access. Cloud computing is flexible in nature. It allocates the resources on the authority request. [2] Cloud computing provides the act of uniting. It is an emerging technology, that is used to provide various computing and storage services over the Internet. In cloud computing, the internet is viewed as a cloud. By the use of cloud computing, the capital and operational costs can be cut. In the older days every company was to license their software through CDs DVDs and when it was to come on upgrading, they were to face lots of problems. When cloud computing comes as a service part like rental the cost of supplying and vendor system could be reduced, where the software comes to any organization directly. Cloud computing incorporates the infrastructure, platform, and software as services. These service providers rent data center hardware and software to deliver storage and computing services through the Internet. Internet users can receive services from a cloud as if they were employing a super computer which be using cloud computing. To storing data in the cloud instead of on their own devices and it making ubiquitous data access possible. They can run their applications on much more powerful cloud computing platforms with software deployed in the cloud which mitigating the users burden of full software installation and continual upgrade on their local devices.

### HOW DOES CLOUD COMPUTING WORK?

Cloud computing aims to apply the power of supercomputer to problems like analyzing risk in financial portfolios, powering immersive computer games, in a way that users can tap through the Web. It does that by networking large groups of servers that often use low-cost consumer PC technology, with specialized connections to spread data-processing chores across them. Soon instead of installing a suite of software for each computer, you'd only have to load one application. That application would allow workers to log into a Web-based service which hosts all the programs. Remote machines owned by another company would run everything from e-mail to word processing to complex data analysis programs. It's called cloud computing. The only thing the user's computer needs to be able to run is the cloud computing systems interface software, which can be as simple as a Web browser, and the cloud's network takes care of the rest. The software and storage for your account doesn't exist on your computer -- it's on the service's computer cloud. Cloud computing providers deliver applications via the internet, which are accessed from a Web browser, while the business software and data are stored on servers at a remote location. In some cases, legacy applications (line of business applications that until now have been prevalent in thin client Windows computing) are delivered via a screen-sharing technology such as Citrix Xen App, while the computing resources are consolidated at a remote data center location; in other cases, entire business applications have been coded using web-based technologies such as AJAX.

A simple example of cloud computing is Yahoo email, Gmail, or Hotmail etc. You don't need software or a server to use them. All a consumer would need is just an internet connection and you can start sending emails. The server and email management software is all on the cloud (internet) and is totally managed by the cloud service provider Yeah, Google etc. The consumer gets to use the software alone and enjoy the benefits. The analogy is, 'If you need milk, would you buy a cow?' All the users or consumers need is to get the benefits of using the software or hardware of the computer like sending emails etc. Just to get this benefit (milk) why should a consumer buy a (cow) software /hardware? Cloud computing is broken down into three segments: "application" "storage" and "connectivity." Each segment serves a different purpose and offers different products for businesses and individuals around the world. In June 2011, a study conducted by VersionOne found that 91% of senior IT professionals actually don't know what cloud computing is and two-thirds of senior

finance professionals are clear by the concept,[5] highlighting the young nature of the technology. In Sept 2011, an Aberdeen Group study found that disciplined companies achieved on average an 68% increase in their IT expense because cloud computing and only a 10% reduction in data center power costs[6]. Final Version of NIST Cloud Computing Definition[7] Cloud computing is a relatively new business model in the computing world. According to the official NIST definition, "cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

## RELATED WORK

The researches on exploiting renewable energy in data centers have been recently active. Le et al. (2009) proposed a framework for optimization-based request distribution in multi-data-center internet services, and two policies for managing these services' energy consumption and cost respecting their service level agreements (SLAs). Stewart and Shen (2009) discussed how to maximize green energy use in data centers and focused on request distribution in multi-datacenter interactive services. Zhang et al. (2011) presented the GreenWare, a novel middleware system that conducts dynamic request dispatching to maximize the percentage of renewable energy used to power a network of distributed data centers, subject to the desired cost budget of the Internet service operators. Goiri et al. (2011) proposed the GreenSlot, a parallel job scheduler for data centers partially powered by solar energy. The GreenSlot predicts solar energy availability two days into the future, and schedules jobs to maximize the use of green energy and limit brown energy costs using the predictions and avoiding deadline violations. Krioukov et al. (2012, 2011) suggested green energy-aware job schedulers for a single data center, and explored the scheduling of workload to match the available renewable energy supply to enable using more intermittent renewable energy. Liu et al. (2011b) investigated whether geographical load balancing can encourage the use of green renewable energy and reduce the use of brown fossil fuel energy. Besides, three distributed algorithms were proposed for achieving optimal geographical load balancing. Goiri et al. (2012) provided the GreenHadoop, a MapReduce framework for a data center powered by a photovoltaic solar array and the electrical grid. Goiri et al. (2013) presented the Parasol, a prototype green data center built as a research platform, and the GreenSwitch, a model-based approach for dynamically scheduling the workload and selecting the source of energy to use. Deng et al. (2013) applied the two-stage Lyapunov optimization design an online control algorithm – SmartDPSS, which optimally schedules multi-source energy to power a data center with arbitrary demand in a cost minimizing fashion.

## CARBON EFFICIENT VM PLACEMENT AND MIGRATION TECHNIQUE

From the literature survey, it is found that various research works have been done to attain energy efficiency and reduce power consumption. However, a very few researchers have tried to focus primarily on reduction of carbon footprint as discussed above. To the best of knowledge none of the above mentioned techniques have considered both the factors together, i.e. reduction of carbon emission in federated cloud datacenters and also minimization of energy consumption inside each data center of cloud by focusing on current utilization of each host. Consideration of utilization of hosts inside the datacenters, during the execution of VMs, is an important factor for minimizing the power consumption [26]. And the optimal utilization can be achieved by using migration techniques whenever required. An approach called Carbon Efficient VM Placement and Migration Technique (CEPM) has been implemented, which is different from all the above mentioned techniques.

- ⊙ Technique follows the distributed cloud architecture in which datacenters are federated over different geographic locations.
- ⊙ Each data center in the distributed cloud architecture has its own carbon footprint rate depending upon its energy resource.
- ⊙ The carbon footprint of the Cloud for a time interval [0,t] with d datacenters having c number of clusters each, and each cluster having h number of hosts is calculated as in equation.

$$CF = \sum_{t=1}^T \sum_{i=1}^d (PUE_i \times \sum_{j=1}^c (cf_j \times \sum_{k=1}^h (P(vm_{i,j,k,t}) \times ht)))$$

- ⊙ 'CF'- is the carbon footprint of the cloud,
- ⊙ 'PUE'- indicates power usage effectiveness
- ⊙ 'ht'- represents holding time for VM.

Approach is divided into two step process:

- i) Initial placement of VM to a suitable host from the datacenter having minimum carbon footprint rate among all the available hosts from different distributed data centers.
- ii) Optimization of current VM allocation inside every datacenter.

### First step: Carbon Efficient VM Placement

In the first step, when a new VM request is received by the cloud broker, the broker selects the host from most carbon efficient data center available by looking into the centralized database of all the data centers maintained at the broker site. This centralized data maintains the list of all the available hosts in every datacenter. Also, it maintains the list of datacenters sorted in ascending order of CF\*PUE. From all the suitable hosts which fulfill the requirements of the VM request, the host is selected from the datacenter having the minimum carbon footprint rate in the sorted list of datacenters.

### Second Step: Optimization of current VM allocation

In the second step, we execute the migration process in order to minimize energy consumption inside each data center. The VMs are migrated to other hosts of the datacenter from those hosts which are either over utilized or underutilized depending upon two predefined threshold values of the utilization.

#### ALGORITHM

- ⦿ Receive the request for a VM.
- ⦿ Get the information of datacenters from the central database and sort them in ascending order of value (CF\*PUE).
- ⦿ Get the list of all the available hosts from all the datacenters in the cloud.
- ⦿ From the available hosts, make a list of all the hosts which fulfill the service requirements of the VM.
- ⦿ From the list of selected hosts, get the host belonging to the most carbon efficient datacenter
- ⦿ Allocate the host to the VM.
- ⦿ If there are more than one host from the list of suitable hosts, which belong to most carbon efficient datacenter select the host with minimum increase in power consumption on placement of VM.

### EXPERIMENTAL SETUP

We have conducted multiple experiments by using cloud sim simulator by taking different number of virtual machines and cloudlets. For the simulation, we focus on average response time and the total response time. The average response time and total finishing time is computed in milliseconds. CloudSim is a new generation and extensible simulation platform which enables seamless modeling, simulation, and experimentation of emerging Cloud computing infrastructures and management services to be]. CloudSim is used to verify the correctness of the proposed algorithm. CloudSim toolkit is used to simulate heterogeneous resource environment and the communication environment. Cloud resources are depicted as some parameters, such as VM ID, processing elements, processing capability (MIPS), bandwidth, RAM, cost and so on in TABLE 1. In this experiment, 5 cloud resources are created to simulate the experiments. The bandwidth, processing capability of resources are main factors that we consider in this experiment. The experiments are conducted several number of times by taking different number of cloudlets like 1000,2000,3000 and so on. The average response time and total response time have been computed as below in Table 1.

**Table 1. Total Response Time and Average Response Time**

| No of Cloudlets | Total Response Time | Avg. Response Time |
|-----------------|---------------------|--------------------|
| 10              | 2293                | 229.3318333        |
| 100             | 24858               | 248.5817133        |
| 500             | 119401              | 238.801384         |
| 1000            | 228061              | 228.0612425        |
| 5000            | 1141227             | 228.2454004        |
| 10000           | 2297500             | 229.7500331        |

**Processing Time/ Execution Time:** The time from the submission of a request to the time of first response by the cpu. It is the amount of time it takes to get first response for the request submitted. Table 2 depicts the start time and finish time of 15 cloudlets at different virtual machines.

**Table 2. Start Time and Finish time of each Cloudlet**

| CLOUDLET ID | VMID | TIME   | START TIME | FINISH TIME |
|-------------|------|--------|------------|-------------|
| 0           | 0    | 184.23 | 0.1        | 184.33      |
| 1           | 5    | 791.72 | 0.1        | 791.82      |
| 2           | 10   | 974.75 | 0.1        | 974.85      |
| 3           | 15   | 943.58 | 0.1        | 943.68      |
| 4           | 20   | 208.52 | 0.1        | 208.62      |

|    |    |        |     |        |
|----|----|--------|-----|--------|
| 5  | 25 | 965.72 | 0.1 | 965.82 |
| 6  | 30 | 378.38 | 0.1 | 378.48 |
| 7  | 35 | 287.31 | 0.1 | 287.41 |
| 8  | 40 | 171.23 | 0.1 | 171.33 |
| 9  | 45 | 84.94  | 0.1 | 85.04  |
| 10 | 50 | 304.02 | 0.1 | 304.12 |
| 11 | 55 | 487.84 | 0.1 | 487.94 |
| 12 | 60 | 617.45 | 0.1 | 617.55 |
| 13 | 65 | 284.22 | 0.1 | 284.32 |
| 14 | 70 | 42.37  | 0.1 | 42.47  |

We have simulated 25 virtual machines with different values of carbon footprint and PUE. All the virtual machines in the cloud are connected to the cloud broker. Each datacenter consist of 10 heterogeneous physical nodes. The values of carbon footprint and PUE of each virtual machine is as mentioned in the Table 3. Each physical node is modelled to have the configuration according to the Table II and the requirements of a VM in the simulation model are as given in Table III.

**Table 3. Calculation of CF and PUE**

| VMID | RAM (MB) | MIPS | BW  | CF       | PUE    | VALUE=CF*PUE |
|------|----------|------|-----|----------|--------|--------------|
| 0    | 100      | 100  | 300 | 0.6147   | 0.6123 | 0.37638081   |
| 1    | 100      | 200  | 300 | 0.732342 | 0.7467 | 0.5468397    |
| 2    | 100      | 300  | 300 | 0.823424 | 0.8333 | 0.686159     |
| 3    | 100      | 400  | 300 | 0.91234  | 0.934  | 0.84245475   |
| 4    | 100      | 500  | 300 | 0.9784   | 0.956  | 0.935293     |
| 5    | 100      | 100  | 300 | 0.6147   | 0.6123 | 0.37638081   |
| 6    | 100      | 200  | 300 | 0.732342 | 0.7467 | 0.5468397    |
| 7    | 100      | 300  | 300 | 0.823424 | 0.8333 | 0.686159     |
| 8    | 100      | 400  | 300 | 0.91234  | 0.934  | 0.84245475   |
| 9    | 100      | 500  | 300 | 0.9784   | 0.956  | 0.935293     |
| 10   | 100      | 100  | 300 | 0.6147   | 0.6123 | 0.37638081   |
| 11   | 100      | 200  | 300 | 0.732342 | 0.7467 | 0.5468397    |
| 12   | 100      | 300  | 300 | 0.823424 | 0.8333 | 0.686159     |
| 13   | 100      | 400  | 300 | 0.91234  | 0.934  | 0.84245475   |
| 14   | 100      | 500  | 300 | 0.9784   | 0.956  | 0.935293     |
| 15   | 100      | 100  | 300 | 0.6147   | 0.6123 | 0.37638081   |
| 16   | 100      | 200  | 300 | 0.732342 | 0.7467 | 0.5468397    |
| 17   | 100      | 300  | 300 | 0.823424 | 0.8333 | 0.686159     |
| 18   | 100      | 400  | 300 | 0.91234  | 0.934  | 0.84245475   |
| 19   | 100      | 500  | 300 | 0.9784   | 0.956  | 0.935293     |
| 20   | 100      | 100  | 300 | 0.6147   | 0.6123 | 0.37638081   |
| 21   | 100      | 200  | 300 | 0.732342 | 0.7467 | 0.5468397    |
| 22   | 100      | 300  | 300 | 0.823424 | 0.8333 | 0.686159     |
| 23   | 100      | 400  | 300 | 0.91234  | 0.934  | 0.84245475   |
| 24   | 100      | 500  | 300 | 0.9784   | 0.956  | 0.935293     |



## CONCLUSION

The growing demands of consumers for computing services are encouraging the service providers to deploy large number of data centers, all over the world that consume very large amount of energy. Increasing amount of energy consumption by the datacenters is one of the reasons of increase in the level of carbon dioxide in our ecosystem. Research gives an idea that one google search generates as much CO<sub>2</sub> as car produces by driving 3 inches and could power a 100 watt light bulb for 11 secs. All monthly google search generate 2,60,000 kg CO<sub>2</sub> which requires 39,00,000 KWh energy. According to gartner the information and communication industry produces 2 % of global carbon dioxide emission. In the future work, we will try to optimize the power consumption by the datacenter, thereby saving the cost occurred to the client and the cloud provider. By reducing the power consumption, we will be able to reduce the carbon footprints and will lead to much cleaner and greener environment.

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