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Energy-Aware Virtual Machine Placement

Maredu Sairam, Student

Computer science Engineering, Chaitanya Bharathi Institute of Technology, Hyderabad, Telangana, India

ABSTRACT

Cloud data centers consume a large amount of energy that leads to a high carbon footprint. Taking into account a carbon tax imposed on the emitted carbon makes energy and carbon cost play a major role in data centers' operational costs. To address these challenges, we required the parameters that have the biggest effect on energy and carbon footprint cost to propose more efficient VM placement approaches.

In this work, we calculate the total energy cost consumed by servers plus overhead energy, which is computed through power usage effectiveness (PUE) metric as a function of IT load and outside temperature. The main contribution of this work lies in comparing the different VM placement approaches by calculating the cost of energy consumed and the carbon tax and we also consider total available renewable resources in the datacentre site and carbon footprint cost. This study shall help the cloud providers to select the best VM placement approach to minimize their maintenance cost of a datacentre.

Index Terms- **Data Center(DC), DC Energy Consumption, Green Energy (Renewable Resources), Carbon Foot Print, VM placement**.

1. INTRODUCTION

Cloud computing brought a revolutionary changes in the IT sector where every organization is migrating to cloud computing. Cloud computing is considered a big step towards the long-held dream of delivering computing as a utility to users. The cloud enables access to hardware resources, infrastructure, and software anytime and anywhere on a pay-as-you-go model. Services by cloud computing are delivered by data centers that are distributed across the world, which can host small numbers to thousands of servers. A major issue with these data centers is that they consume a large amount of energy. According to a report from NRDC, US data center power consumption estimation alone in 2013 was 91 billion kilowatt-hours of electricity. This is equivalent to two years' power consumption of New York City's households and is estimated to increase to 140 billion kilowatt-hours by 2020, which is responsible for the emission of nearly 150 million tons of carbon pollution.

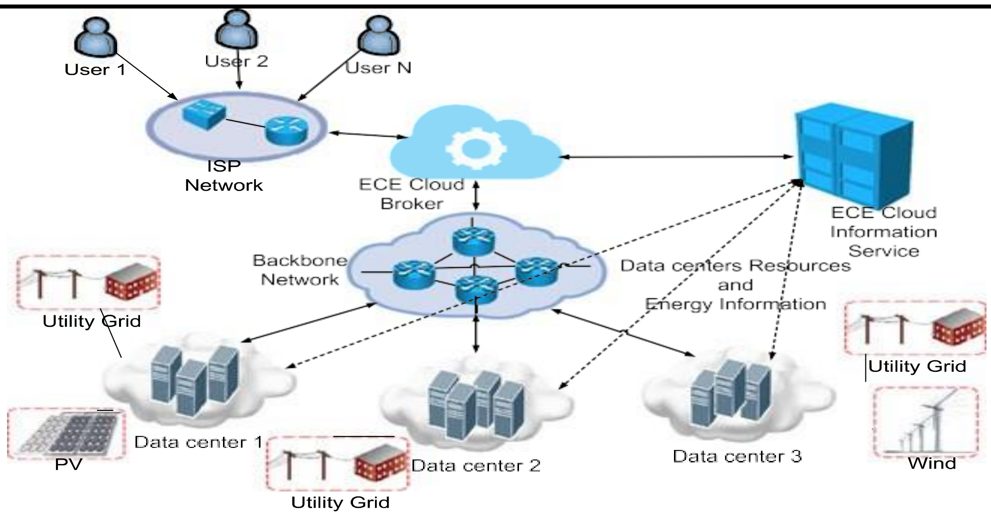

Fig: 1 System model for geographically distributed green cloud computing environment

The list of parameters that affect the total cost associated with the energy consumption and carbon footprint for a cloud provider. Here, it only considers the cost of these two parameters, unless otherwise mentioned. A cloud provider often maintains geographically distributed data center sites, similar to popular cloud providers (e.g., Amazon, Google, and Microsoft). Having several sites not only increases the availability, it also gives the cloud provider the option of choosing the destination site based on different criteria upon the reception of the user request (virtual machine requests in this paper). There are different challenges a cloud provider faces to make the decision regarding VM placement and scheduling. We study the selection process among several data center sites. Each data center can get its electricity from different electricity providers, we refer to this as off-site brown energy sources, or even can draw the required electricity from on-site renewable ("green") energy sources, such as solar and wind. Having data center sites that can get their power from renewable sources partially or completely helps the provider decrease its dependency on the electricity drawn from off-site grids, which is costly and less clean. Second, off-site brown energy at different locations have different carbon intensities and carbon taxes. Therefore, by the change of the availability of renewable energy during the day and in the case that they are not available, cloud provider can select the cleanest source of electricity with less carbon tax. The third advantage of having different energy sources at different locations is changes in electricity price, as we consider variable energy pricing during times of the day, i.e., on-peak and off-peak prices.

The last and one of the most important parameters that affects data centers energy consumption, carbon footprint, and their associated cost is the overhead power, e.g., power supplies, cooling, lightning, and UPS. The metric used to demonstrate the overhead is known as Power Usage Effectiveness (PUE) that is defined by The Green Grid consortium. PUE is equal to the data center's total power consumption, which is the input power that goes to the data center, divided by the IT devices power consumption.

$$PUE = \frac{Total\ Power\ of\ Datacenter}{IT\ Devices\ Power}$$

If PUE is equal to 1 it means that the data center is perfectly efficient, which is not practically attainable. An increase in PUE indicates more waste of power to support IT devices in the data center.

Cloud providers often collocate with smaller data centers, which can still have PUEs up to 2[1],[2]. To increase a data center's efficiency, we should identify variables that have the highest impact on the increase of the system's overhead power. The main variable that affects efficiency and PUE value is IT load. When the IT load is increased, CPUs perform in higher frequencies and servers consume more power. This leads to increase in data center's overall load and in side temperature; accordingly the need arises for more power for the cooling of the infrastructure. The second important variable that affects PUE is the outside temperature, which has a great effect on the cooling system power consumption. As outside temperature increases, the data center needs to use the chillers along with the computer room air handler (CRAH), which leads to a significant increase in the power consumption and PUE value. We exploit a model for PUE as a function of IT load and outside temperature and perform VM placement based on dynamic changes of PUE.

1.1 Existing System

The present system identified the some of the problems facing by the cloud provider and cloud date centre and developed couple of methods to overcome with their problems. The commonly used methods are scheduling methods like round robin and unbalance for scheduling the cloudlets on the VM's, Dvfs (dynamic voltage and frequency) for making servers energy efficient by considering hardware aspects, VM's are migrated between the servers and date centre's based on the load of the server's. The utilization of datacentre is increased the energy consumed by data centres is also increased high costs to cloud providers since energy-related costs are the most significant cost for a data centre. Furthermore, to enforce environmental sustainability, some countries set a carbon tax on the emitted CO2. Therefore, monitoring the amount of energy consumed by a data centre and the source of the energy, which directly affects the carbon footprint and carbon tax, helps cloud providers to reduce the energy and carbon cost as a major sector of their total cost.

1.2 Problem Definition

- The main problem with Datacentres is VM placement is not done in an organized manner at servers. Due to this entire data centre should be active and energy consumption will be increase.
- To overcome this problem VM placement has to be done another server after fully utilized one server.
- To minimize the cost of energy consumption datacentre have to shut down the servers that are not in use as idle servers uses more energy.

1.3 Objectives

The objective of the VM Placement Method for Minimizing Energy and Carbon Cost are as follows:

1: To minimize energy consumption by data centres.

2: To estimate the Carbon Tax of the datacentre for carbon emission to produce and electricity in absence of other resources carbon.

3: To maximizes renewable energy utilization at each data centre and to minimize the total cost.

4. To select the data centre with maximum availability of renewable energy and PUE.

1.4 Proposed System

- In this work, a three different VM placement approach is implemented by considering both Energy consumption and carbon tax cost.
- The PUE as a function of IT load and outside temperature to incorporate overhead energy consumption, e.g., power supplies, cooling, lightning, and UPS, along with the energy consumed by the servers.
- Used different carbon intensities and carbon taxes for energy sources at each data centre site.
- Analysed the effect of distributing load among data centers sites with access to intermittent renewable energy sources

The key contribution of this work is to implement VM placement by considers all geographically distributed cloud data centers that simultaneously considers the cost of 1) overhead energy 2) servers' energy and 3) carbon footprint. Moreover, the implemented VM placement method maximizes renewable energy utilization at each data center to minimize the total cost. Finally, we present efficient VM placement approaches that respond to dynamic PUEs. We also compare with other already existing model, which explore the effects of different parameters in minimizing energy and carbon cost for a cloud computing environment. To achieve this, we have carried out the following:

- This work used an analytical model for calculating the total cost incurred by the energy consumption and carbon footprint for the data centres.
- The PUE as a function of IT load and outside temperature to incorporate overhead energy consumption, e.g., power supplies, cooling, lightning, and UPS, along with the energy consumed by the servers.
- Used different carbon intensities and carbon taxes for energy sources at each data center site.

1.5 Organization of the Dissertation

The overall discussion of this report is organized as follows: in Section 2, the related work and existing approaches are discussed, Section 3 discusses the design and model of system, parameters, and constraints, Section 4 will discuss about how we implement and with their characteristics and specifications. In sections 5 we discuss about Result we got by comparing with other approaches. Finally, Section 6 concludes about our work and presents future directions.

2 Literature Survey

Over the past few years, the studies and researches on Data Center and its energy consumption have been increased drastically. The main aim of this all research and studies are to optimize and minimize the energy consumption of these datacenters. As of now, most IT sectors are relying on cloud computing the challenges of the cloud providers as also been increased. Some of them are providing services with any disturbance, quality of data, computation power, and unlimited storage. To satisfy the cloud using all data center have to be in an active state, this data center consumes a large amount of energy. In the absence of utility grid data centers uses generators that consume non-renewable resources to produce energy. This non-renewable resource releases CO2 into the environment that shows impacts on global warming for this some countries set carbon tax on the emitted Co2.

Most of the early work focuses on making single server energy efficient by considering hardware aspects and using techniques such as CPU DVFS (dynamic voltage and frequency scaling)[3]. Moreover, virtualization as the foundation of cloud computing systems enables consolidation and VM migration. There is ongoing research on the later techniques, but the main issue is that they are reactive and require a resume and suspension of VMs which cause overhead to the system. Therefore, these techniques should be applied only when they are cost-effective.

M. Lin, A. Wierman, L. Andrew[4], and D. Shen [5] used a pro-active technique, known as dynamic right-sizing, to predict the number of active servers needed to host the incoming workload. Since idle servers consume almost half of the peak power, this technique could reduce the energy consumption significantly. Then, the first works to reduce cost and brown energy consumption by load distribution among several data center sites.

Lefevre [6] proposed an advanced resource reservation architecture to have a better prediction of the incoming requests by users. The above-mentioned techniques are in the scope of a single data center and they only consider the aspect of reducing energy consumption; which does not necessarily lead to a reduction in the carbon footprint.

Aksanli [7] uses predication-based algorithms to maximize the usage of renewable energy sources and in the meantime minimize the number of canceled jobs.

Their work is based on considering the electricity price and energy source (green or brown) to calculate the number of requests each data center can host within a specific time period and budget. However, they do not differentiate among sites that have brown energy sources with different carbon emission rates. Further, the incoming workload is based on SaaS (Software as a Service) requests for Internet services with short processing times, usually in milliseconds.

Z. Liu, M. Lin[8] considers geographical load balancing to minimize brown energy consumption as well. They use an optimal mix of renewable energy (solar and wind) along with energy storage in data centers to eliminate brown energy consumption. Lin et al. [22] extended the previous work to find the best estimate combination for solar and wind energy while having net-zero brown energy usage. The Min Brown workload scheduling algorithm is proposed by Chen, to minimize brown energy consumption. This algorithm forwards the incoming request to all data centers, then based on the request deadline and brown energy consumption schedules request for execution.

In 2013 Celesti[9], proposed a federated CLEVER-based cloud environment; which is based on the allocation of VM requests to the cloud data center with the highest amount of solar energy and lowest cost.

In 2010 K. Le[10], R. Bianchini, T. D. Nguyen, proposed an optimization-based framework to minimize brown energy consumption and leverage green energy through distribution of the Internet services to the data centers, considering different electricity prices, data center location with different time zones, and access to green energy sources.

In 2011 K. Le[11], J. Zhang, apply dynamic load distribution policies and cooling strategies to minimize the overall cloud provider's cost but places no cost on carbon emissions. Their work is based on the intelligent placement of VM requests on data centers considering the geographical location, time zone, energy price, peak power charges, and cooling system energy consumption.

In 2012 S. Ren, Y. He, and F. Xu, [12] proposed a provably efficient on-line algorithm (GreFar) with the objective to minimize energy cost. They use servers' energy efficiency information and locations with low electricity prices to schedule batch jobs and, if necessary, suspend the job and resume later.

Work by Goiri, aims to find the best place for a data center, based on geographical location and data center characteristics to minimize cost, energy consumption, and carbon footprint.

In 2011 S. K. Garg, C. S. Yeo, [13] proposed an environment-conscious meta-scheduler to minimize carbon emission and maximize the cloud provider's profit. They used near-optimal scheduling policies to send HPC (high-performance computing) applications to the data center with the least carbon emission and maximum profit, considering application deadline. They also address the issue of energy consumption and carbon footprint by proposing a novel green cloud architecture. This architecture uses two directories so the cloud providers can register their offered services. A notable work by Buchbinder has the same objective of reducing the energy cost of a cloud provider with multiple data center sites. They perform online migration of running batch jobs among data center sites, taking advantage of dynamic energy pricing at different locations, while considering the network bandwidth costs among data centers and future changes in electricity price. Similarly,

In 2013 Rajkumar Buyya , Saurabh Kumar Garg[14]: They have noticed that due to using brown energy the corban is emitted into the environment by this carbon tax is also added to the maintenance of the datacenter. So, they developed an algorithm named "Energy and Carbon-Efficient (ECE) VM Placement Algorithm" to minimize the carbon emission.

In 2015 M. Giacobbe, A. Celesti, M. Fazio, [15]: perform VM migration between cloud data centers participating in a federated environment to push down energy costs. They take advantage of dynamic electricity pricing to migrate the VMs to the data center with the lowest energy cost and enough resources. He also uses the idea of migrating VMs in a federated cloud environment to reduce carbon footprint. They move the VMs from a high carbon footprint source to a data center with access to solar energy, using a two-step approach.

In 2019 Yun Tian and Shu Yin [16] : They have noticed that after VM is allocated if the usage of VM is exceeded then the workload on the VM is increased, they have developed a model called "VM allocation and VM migration based on PPR (Performance to Power ratio) of servers. CPU with high PPR is considered as the best CPU. They separated the servers as over utilized and underutilized. Based on this VM migration is done.

In 2019 N. Kortas and H. Youssef[17]. They have noticed that for VM migration extra energy is used so they developed two types of networking environment name 1) Two-tier architecture 2) Tree-tier architecture. They have included new racks in tier one that are connected with switches in tier two with high-speed links 10GE by this workload can be managed by adding extra computing resources.

2.1 Similar problems in all methods are

1) To minimize energy consumption.
2) Load balance techniques.
3) VM migration between the Servers and Datacentres.
4) To minimize the carbon emission and carbon tax.

2.2 Limitations and drawbacks of this all approach's

1) Extra energy is used by newly added servers and IT devices.

2) The extra energy is required for VM migration between the datacentres.

3) As the surrounding temperature increases the cooling equipment consumes high energy.

2.3 Advantages:

1) The utilization of servers has increased.

2) The utilization of renewable energy resources has been increased.

3) The energy consumption of the data centre is minimized.

4) Energy consumed by the migration is also minimized.

5) The maintenance cost of the cloud provider is decreased.

3 System Design and Model

In this section, we discuss how we have developed our model with system architecture and its components with their role in the system. This system will depend on the cloud computing environment and its backbone data center which consumes a large amount of energy. Then, we discuss all the parameters that affect the energy consumption of data centers which directly minimize the maintains cost of a cloud provider. We mainly focus on how VM is elongated by considering corban footprint energy consumption and their associated costs and we also state objective functions and relevant constraints of the model and we list the symbols used in our model.

The developed system is applied for IAAS cloud provider offering VM resources to clients which is similar to elastic compute cloud EC2 service to amazon web service.

3.1 System Architecture

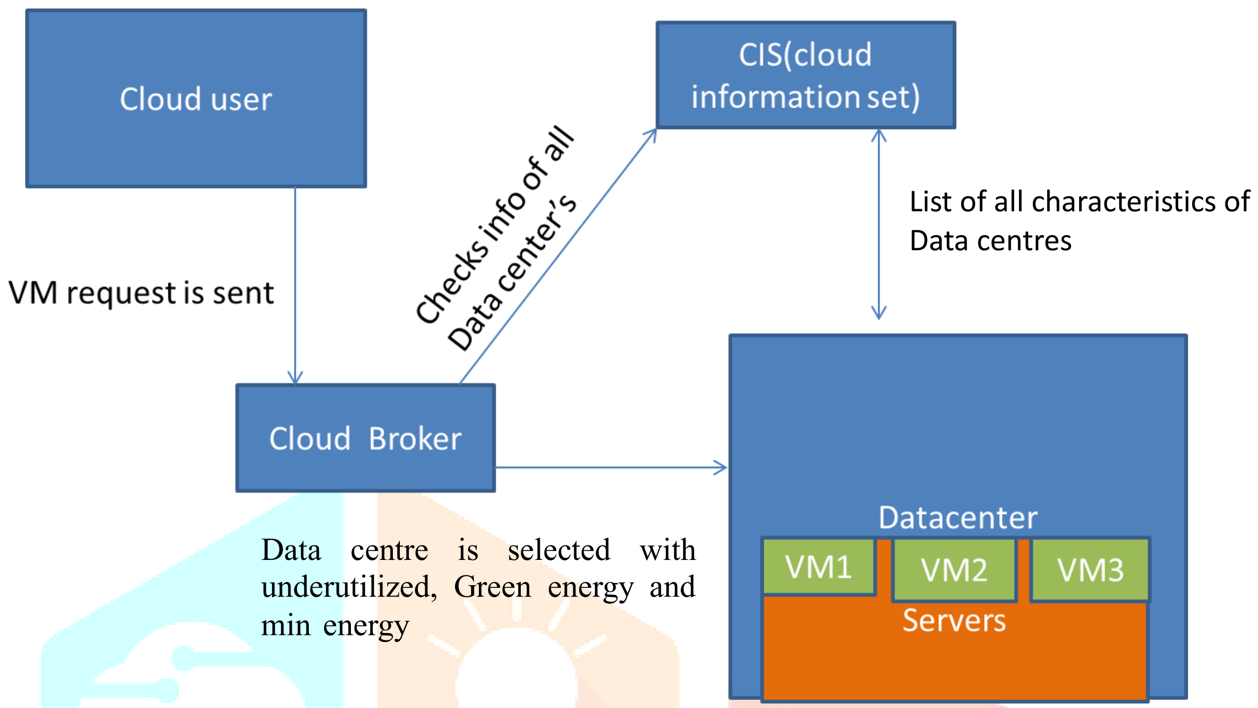

Fig: 2 System Architecture of CA-DP and EA-DP

3.2 System Components:

The Main components of cloud computing systems are Cloud provider, cloud broker, cloud users these roles are discussed below.

3.2.1 Cloud Provider

The cloud provider consists of multiple data centers that are distributed geographically in a different location over the world and these are connected with high bandwidth networks. Each data center site D is connected to a backbone network to serve cloud users and each data canter uses one or more energy sources to provide electricity for its networking equipment servers, power system, and other devices.

3.2.2 Cloud Broker:

Cloud broker is a component which plays the main role in cloud computing, it receives a VM request from the users and routes them to data site then place on the server. The cloud broker should route in such a manner that minimizes the energy consumption and relative cost and they should also maintain balance workload.

3.2.3 Cloud Users

Cloud users submit their VM requests to the cloud broker. A submitted VM request from user i, at time t can be shown as the pair vi = (Type, HoldTime). VM type is inspired by Amazon EC2 VM instance types and VM hold time depends on the application that will be run on that VM. In practice, the arrival time, type, and hold time of a VM is not known by the cloud provider in advance. In our model, we serve all the VMs based on their arrival time on a first-come first-serve basis. Cloud users need to have a quality of experience (QoE) that must be satisfied by the cloud provider. The QoE for the users is defined in terms of acceptance of the submitted VM requests, which means a lower rejected number of VMs higher QoE for the users. Interaction between cloud user, Broker, and Provider is shown in the fig below.

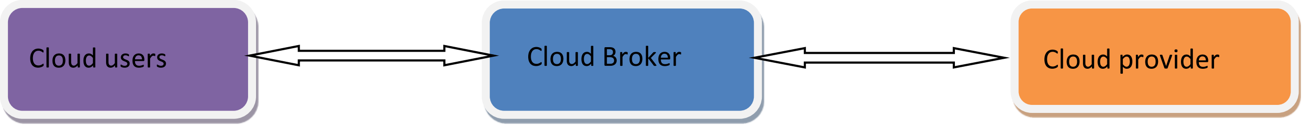

Fig: Inter action between Cloud user, cloud broker, cloud provider

3.3 System Parameters

System Parameters that affect power consumption are as follows:

3.3.1 Data Center Power Consumption

As data center power consumptions are directly or indirectly depends on our side environment. Datacenter uses server power, switches, UPS, Networking devices, and much other equipment. So, to power this all devices datacentre uses energy (power) resources like an off-site grid, local brown, local green, and etc. The cost of energy will be differ based on what type of energy is used by the data center.

3.3.2 PUE Calculating the (Power Usage Effectiveness)

One of the most important parameters that affect data center's energy consumption, carbon footprint, and associated cost is the overhead power, e.g., power supplies, cooling, lightning, and UPS. The metric used to demonstrate the overhead is known as Power Usage Effectiveness (PUE) that is defined by The Green Grid consortium. PUE is equal to the data center’s total power consumption, which is the input power that goes to the data center, divided by the IT device's power consumption. If PUE is equal to1it means that the data center is perfectly efficient, which is not practically attainable. An increase in PUE indicates more waste of power to support IT devices in the data center.

3.3.3 Renewable Energy sources and Energy price

Large cloud providers like Facebook, Google, Apple uses renewable energy to reduce their dependency on the electricity delivered from the off-site utility grid as they are costly and less clean. Data centres built their own on-site wind mills and solar photovoltaics to produce their own power and use for the datacentre. It is a one-time investment process and later just they have to maintain them if any damage occurs. The maintenance cost is decreased when we compare it with the off-site utility grid. However, we have many problems using this approach like 1) Battery-related costs can dominate the cost of a renewable power system, 2) Battery incur energy losses due to internal resistance and self-discharge, and 3) Batteries uses chemicals that are harmful to the environment. In the absence of green energy, the datacentre has to use the electricity from off-site grid utility the cost may differ from place to place it depends on which county the datacentre is located. The electricity is measured in kWh (kilowatt-hour)

3.3.4 Carbon Footprint Rate and Carbon Tax

In the absence of the electricity and renewable source, the datacentre uses generators that produces power using natural resources like (diesel, gas, petrol) these emits an amount of carbon dioxide that affects the environment for this some countries set carbon tax on the emitted Co_2 this tax will also added in the maintenance of datacenter.

$$\text{PUE}(U_t, H_t) = \frac{P_{Total}}{P_s^{U_{st}}} = \frac{P_o + P_s^{U_{st}}}{P_s^{U_{st}}}$$

$$P_o = Overhead\ power$$

$$P_s^{U_{st}} = \ Server\ power\ at\ time\ t\ and\ utilization\ U_{st}$$

$$H_t = Datacenter\ out\ side\ temperature\ at\ time\ t$$

$$U_t = Datacenter\ utilization\ at\ time\ t$$

4 IMPLEMENTATION

4.1 VM Placement Methods and Data Set

In this section, we implemented a dynamic VM placement algorithm that neglects different components of the cost, to study the effect of different parameters and combinations of them on the amount of green and brown energy usage, carbon footprint, and total energy and carbon cost of the cloud data centers.

4.1.1 Cost-Aware with Dynamic PUE (CA-DP)

The CA-DP algorithm by L. H. Andrew, and Rajkumar Buyya [18] is considers that the data center site has renewable energy available, all the servers and racks are always powered by green energy, unless there is not enough renewable energy in the system. In this case, they will get their required power from off-site grid energy sources.

4.1.2 Energy-Aware with Dynamic PUE (EA-DP):

In this method the PUE value is set to zero because it is depends on the outside temperature. It considers average value of PUE and calculates the total energy consumed by the data centre to run the load.

4.1.3 Carbon Footprint-Aware with Dynamic PUE (FA-DP):

As this method calculates the carbon emission by the data centre in pounds per Kilowatt power consumption. This value is depends on the PUE value. This algorithm is a derivation of the ECE algorithm, which considers the effect of PUE and carbon intensity while here PUE has a dynamic value. It selects the data center with the minimum value of PUE.

4.2 Algorithm for CA-DP and EA-DP

Step 1: The list of cloudlets (tasks) from the users maintained and submitted to the cloud broker.

Step 2: This cloudlets will be associated with VM ID, then VM request is send to cloud broker.

Step 3: The cloud broker will check with cloud information set (CIS) where all data centre information is stored.

Step 4: Then data centre is selected which consumes less amount of energy and high availability of green energy.

Step 5: Then Server have to be selected with in the data centre which is underutilized that performs VM selection process.

Step 6: Then cloudlets will scheduled based on Time shared Policy Round Robin.

Step 7: If the cloudlet is completed its execution then output is sent to cloud broker and VM are shut down and deallocated.

4.2.1 ER-Diagram of Model

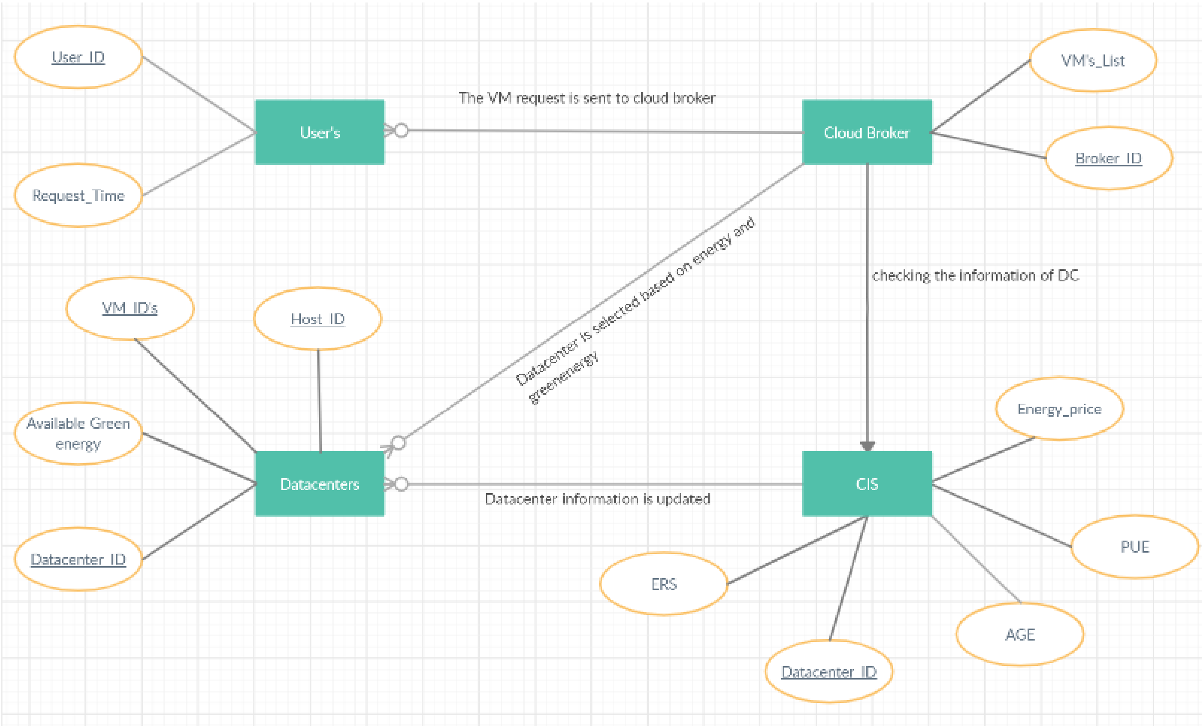

Fig: ER-Diagram of the model.

DCU (Data centre utilization)

AGE (Available green energy)

ERS (Energy required by server)

EP (Energy Price)

CIS (Cloud information Set)

Table 1: Data Center characteristics

List DC	DCU	AGE	ERS	EP (Rs/KWH)	PUE
DC1	0%	1000 Kw	169w	5 rupees	P_o
DC2	50%	1500 Kw	135w	6 rupees	P_o

4.3 Experiment Setup

In order to evaluate the proposed approaches, we target an IaaS cloud computing environment. Since it is difficult to perform large-scale and repeatable evaluation on real infrastructures, we use simulation to conduct our experiments. The CloudSim toolkit is a simulation platform that allows evaluation of virtualized cloud environments. The extended version that enables these features. Apart from adding the energy and carbon-awareness to the CloudSim core, we add other features such as costs of the consumed energy and emitted carbon, access to renewable energy (solar energy in this project), overhead power consumption, and dynamic PUE.

We have developed a virtual environment that takes and input of work load form the user as cloudlet and performs manipulations that date and gives energy consumptions, carbon emission, carbon tax, and cost of energy with and without carbon tax. To do so, we have created a data centre, host, VM's in each host with different parameters.

4.3.1 Data Centre

We have designed a datacentre with different characteristics. The datacentre is the place where multiple number of servers (hosts) are connected with each other. To operate this servers the data centre should have an operating system and what type of system architecture is used and what type of hypervisor is used to create virtual machines. The parameters that calculate the cost of the data centre for the usage of memory, bandwidth, and CPU.

Datacentres Characteristics:

Type of system Architecture used= "x86";
Operating System = "Linux"
Type of vmm = "Xen"
Cost for using processing in this resource = 3.0
The cost of using memory in this resource = 0.05
The cost of using storage in this resource = 0.001
The cost of using bandwidth in this resource = 0.0

4.3.2 Host (Servers in Datacenter)

Server is the main processing unit of the data centre with each may have same memory or a different it is based on the cloud datacentre organization. The server have to be more powerful as it have to process the more work load and they have to use the best quality that gives good life span to decrease the maintenance cost. The server have to hold the capability of the MIPS (millions of instructions per second) and with a specific RAM and bandwidth.

Sevsers Characteristics:

HOST_TYPES = 2
HOST_MIPS = { 1860, 2660 }
HOST_PES = { 2, 2 }
HOST_RAM = { 4096, 4096 }
HOST_BW = 1000000; // 1 Gbit/s
HOST_STORAGE = 1000000; // 1 GB

This are the two different types of servers we have used.
HpProLiantMl110G4Xeon3040(),
HpProLiantMl110G5Xeon3075()

4.3.3 Virtual Machine

A sever with high specification is virtualized and multiple VM (Virtual machines) are created by allocating the server resources like memory, storage, and CPU. To achieve so, Virtualization is used to create multiple virtual machines, where each of these machines has its operating system and applications on a single physical device. A virtual machine can't interact directly with a physical computer. To operate, it needs a lightweight software layer known as a hypervisor, which coordinates between it and underlying physical hardware.

Virtual Machine Characteristics:

Vm_Types = 4;
Vm_Mips = { 2500, 2000, 1000, 500 };
Vm_Pes = { 1, 1, 1, 1 };
Vm_Ram = { 870, 1740, 1740, 613 };
Vm_Bw = 100000; // 100 Mbit/S
Vm_Size = 2500; // 2.5 Gb

Table:2 Virtual Machine Characteristics

VM types	**RAM in mb**	**Memory (vm Size)**	**BW (Amount of Band Width)**	**PES (Amount of CPU's)**	**MIPS (million instructions per sec)**
M1Small	613 Mb	2.5 Gb	100 Mb/s	1	500
M1Large	870 Mb	2.5 Gb	100 Mb/s	1	2500
M1Xlarge	1740 Mb	2.5 Gb	100 Mb/s	1	1000
M2Xlarge	1740 Mb	2.5 Gb	100 Mb/s	1	2000

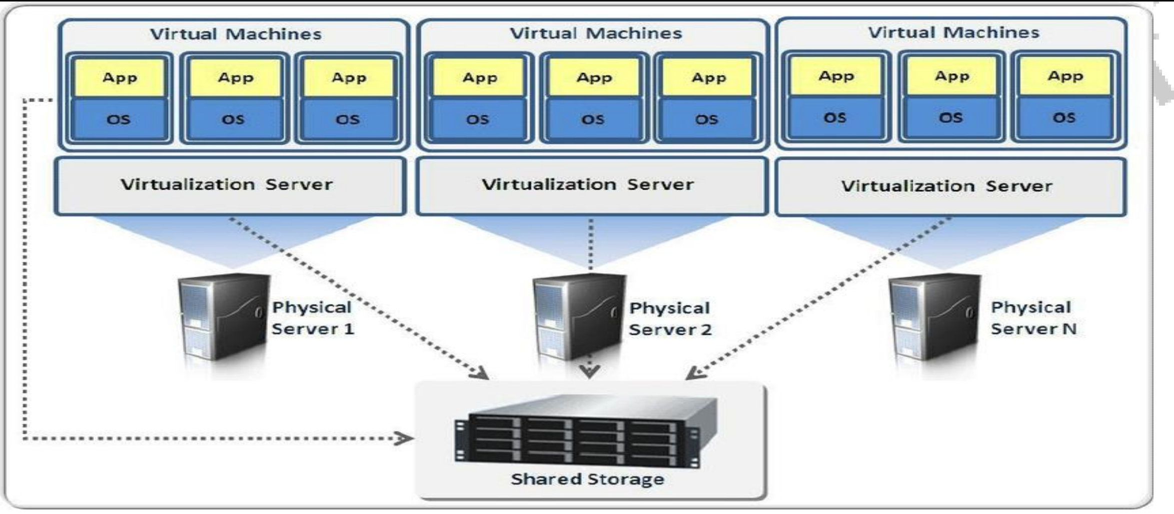

Fig: The diagram representation of Server, Virtual Machine.

4.3.4 Data Set (workload)

The data set or a workload is taken form one of the small datacentre Planetlab. The work load is taken in the form of numeric (numbers) with five minutes of interval that is totally 300 seconds of load. In each VM there are around 300 seconds of load with different cloudlets. This workload is given as input to the data centers.

4.3.5 Server Power of Data Centre

The main aim of this work is to calculate the power consumed by the datacentre. We have taken from the SPEC (Standard Performance Evaluation Corporation) how performs an experiment on the server to take a benchmarks of processer based on utilization of server the power is calculated and benchmarked. As we have used two types of servers the bellow are the specifications and benchmarks.

5 RESULTS AND DISCUSSION

This work measure the total amount of energy consumed, Carbon Footprint, Cost of energy consumed, and carbon tax. Work Load is given to this model and the experiment is done by varying the workload from 1000 VM's to 1500 VM's. If any of the VM gets over loaded then the task VM is migrated to idle VM one. We have taken done the out puts and saved in Excel file and then also compared with other VM placement named Dvfs (dynamic voltage and frequency scaling) this method just allocates the cloudlets to the VM without considering the underutilized or over utilized so the energy consumption of this method will be high. The compression between the Dvfs, CA-DP, and EA-DP then finally discusses which gives better performance and outputs.

The below graph one shows which gives better results. The workload is given same for this three methods and we can state that Cost-Aware with Dynamic PUE and Energy-Aware with Dynamic PUE gives less values when compared with Dvfs with slight value of different.

The bellow second graph is all about cost of energy consumed by the datacentre with different VM placement methods. The cost of carbon tax is also calculated with the current tax rate and energy price in Rs/kWh. If the datacentre uses one-site renewable energy the cost will be minimized.

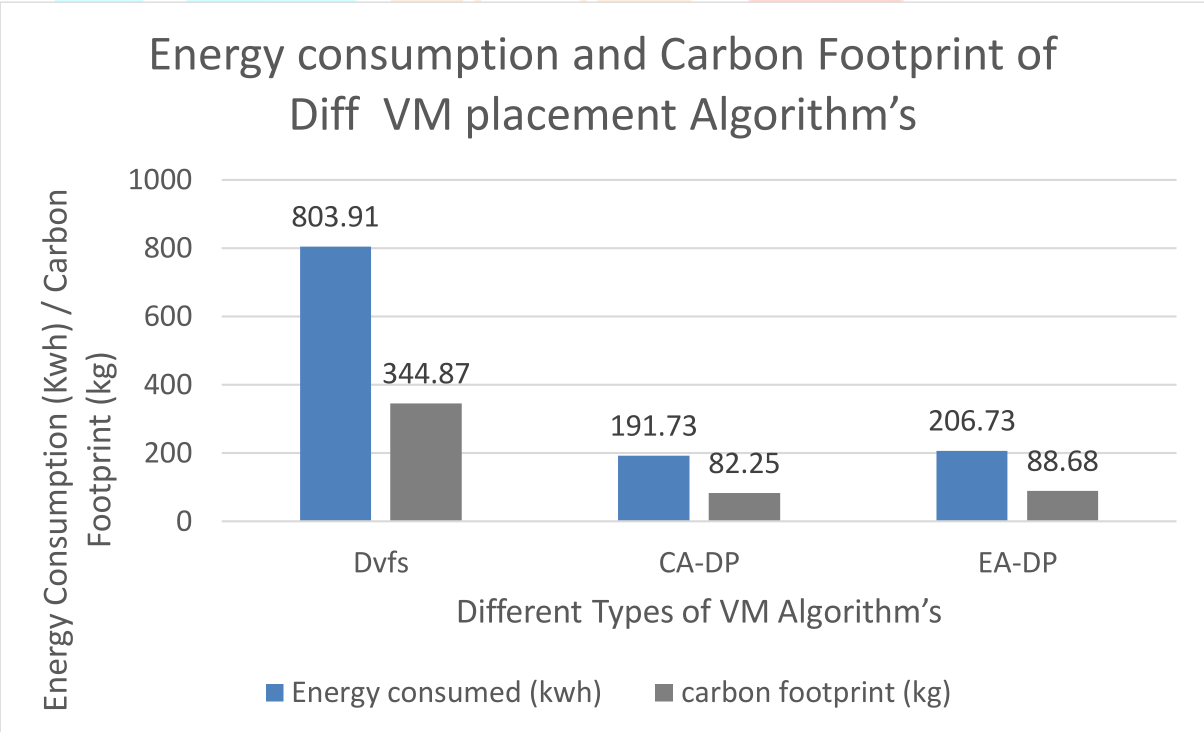

Fig: A graph showing Energy Consumption and Carbon Footprint with different VM placement methods.

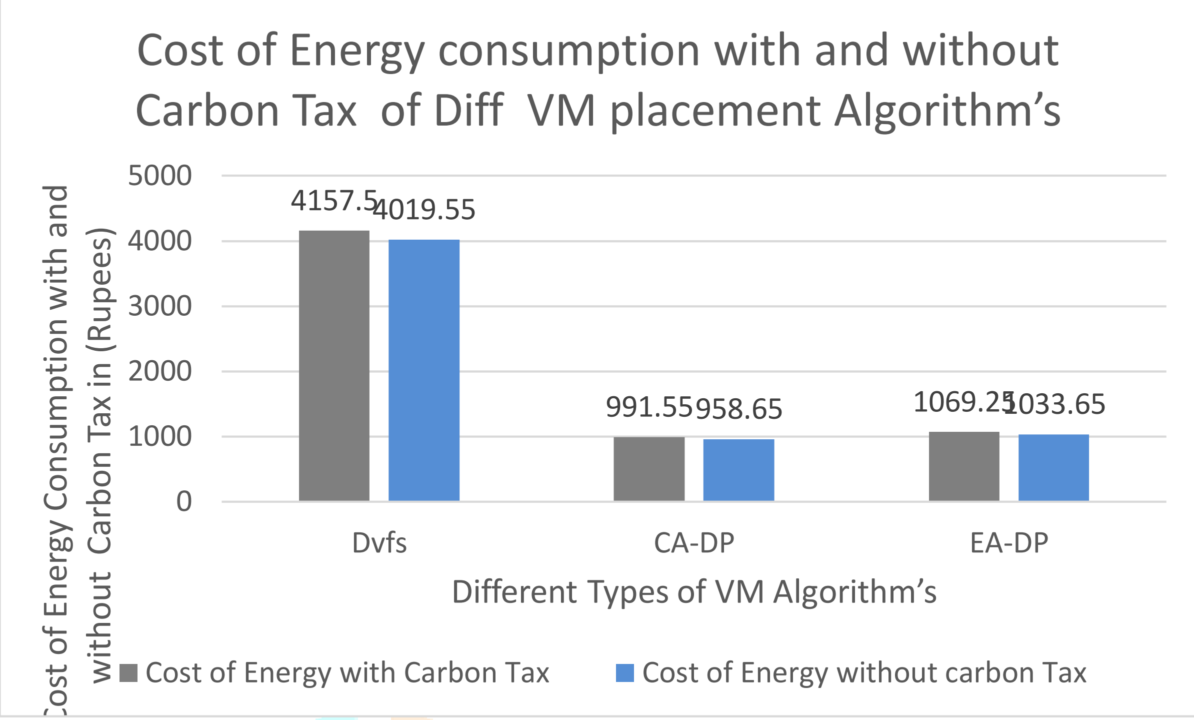

Fig: A graph showing Cost of Energy Consumption with and without Carbon Tax with different VM placement methods.

6 CONCLUSION AND FUTURE ENHANCEMENTS

This project concludes that if data center uses On-site Renewable energy resources then cost for energy consumption will be negligible. This project minimizes the energy and carbon emission by calculating PUE (Power Usage Effectiveness) of each Datacenter. After comparing with other VM placement algorithms we can state that Cost-Aware with Dynamic PUE (CA-DP) and Energy-Aware with Dynamic PUE (EA-DP) consumes minimum amount energy and releases minimum amount of carbon footprint.

Limitations of this work is as workload increases the queue at broker will also increases and waiting time for VM at the broker will be increased by this SLA services level agreement will be effected. The VM request waiting time is also depends on selection process done at CIS by cloud broker. The services level agreement (SLA) is the satisfactions of user with services provided by the cloud provider. If this SLA decreasing the cloud user will switch to other cloud provider that effect's the profit of cloud provider.

The future work can be done on maintaining the SLA of each data center by optimizing the time taken for selection and waiting time at broker. This can be improved by VM hold time and estimating the power before selection or updating the information at CIS after calculating the average energy to run the server at high utilization and also the idle server from total number of server in datacentre this may increase the SLA.

References

[1] "Latest Microsoft Data Center Design Gets Close to Unity PUE," [Online]. Available: http://www.datacenterknowledge.com/ archives/2016/09/27/latest-microsoft-data-center-design-getsclose-to-unity-pue/. Accessed on: Apr. 7, 2017.

[2] A. Shehabi, et al., "United states data center energy usage report," Lawrence Berkeley Nat. Laboratory, Berkeley, CA, USA, Rep. No. LBNL-1005775, vol. 4, 2016

[3]C.-M. Wu, R.-S. Chang, and H.-Y. Chan, "A green energy-efficient scheduling algorithm using the DVFS technique for cloud datacenters," Future Generation Comput. Syst., vol. 37, pp. 141–147, 2014.

[4]. M. Lin, A. Wierman, L. Andrew, and E. Thereska, "Dynamic right-sizing for power-proportional data centers," in Proc. IEEE INFOCOM, 2011, pp. 1098–1106.

[5].D. Shen, et al., "Stochastic modeling of dynamic right-sizing for energy-efficiency in cloud data centers," Future Generation Comput. Syst., vol. 48, pp. 82–95, 2014

[6]. L. Lefevre and A. Orgerie, "Designing and evaluating an energy efficient cloud," J. Supercomputing, vol. 51, no. 3, pp. 352–373, 2010.

[7] B. Aksanli, J. Venkatesh, L. Zhang, and T. Rosing, "Utilizing green energy prediction to schedule mixed batch and service jobs in data centers," in Proc. 4th Workshop Power-Aware Comput. Syst., 2011, pp. 5:1–5:5.

[8] Z. Liu, M. Lin, A. Wierman, S. H. Low, and L. L. Andrew, "Geographical load balancing with renewables," ACM SIGMETRICS Perform. Eval. Rev., vol. 39, no. 3, pp. 62–66, 2011.

[9] A. Celesti, A. Puliafito, F. Tusa, and M. Villari, "Energy sustainability in cooperating clouds," in Proc. 3rd Int. Conf. Cloud Comput. and Serv. Sci., 2013, pp. 83–89

[10] K. Le, R. Bianchini, J. Zhang, Y. Jaluria, J. Meng, and T. D. Nguyen, "Reducing electricity cost through virtual machine placement in high performance computing clouds," in Proc. Int. Conf. for High Perform. Comput., Netw., Storage Anal., 2011, pp. 22:1–22:12

[11] K. Le, R. Bianchini, J. Zhang, Y. Jaluria, J. Meng, and T. D. Nguyen, "Reducing electricity cost through virtual machine placement in high performance computing clouds," in Proc. Int. Conf. for High Perform. Comput., Netw., Storage Anal., 2011, pp. 22:1–22:12.

[12] S. Ren, Y. He, and F. Xu, "Provably-efficient job scheduling for energy and fairness in geographically distributed data centers," in Proc. 32nd Int. Conf. Distrib. Comput. Syst., 2012, pp. 22–31

[13] S. K. Garg, C. S. Yeo, and R. Buyya, "Green cloud framework for improving carbon efficiency of clouds," in Proc. 17th Int. Conf. Parallel Process., 2011, pp. 491–502.

[14]. Rajkumar Buyya , Saurabh Kumar Garg. "Energy and Carbon-Efficient Placement of Virtual Machines in Distributed Cloud Data Centers". Springer-Verlag Berlin Heidelberg 2013.

[15]M. Giacobbe, A. Celesti, M. Fazio, M. Villari, and A. Puliafito, "Evaluating a cloud federation ecosystem to reduce carbon footprint by moving computational resources," in Proc. Symp. Comput. Commun., 2015, pp. 99–104

[16]. N. Kortas and H. Youssef . "Energy consumption of virtual machine migration within varied DCN architectures".in IEEE, Conference Paper on 15th (IWCMC) 2019.

[17]. Yun Tian and Shu Yin. “Virtual machine allocation and migration based on performance-to-power ratio in energy-efficient clouds”. In Scopus, journal on Future Generation Computer Systems,2019.

[18]. Atefeh Khosravi, Lachlan L. H. Andrew, and Rajkumar Buyya. “ Dynamic VM Placement Method for Minimizing Energy and Carbon Cost in Geographically Distributed Cloud Data Centers “. In IEEE Transactions On Sustainable Computing, Vol. 2, No. 2, April-June 2017.