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A Study on Virtual Machines Placement in Distributed Cloud Data Centers for Reducing Energy Consumption and Carbon Emission

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Abstract: Cloud Computing has become a buzzword in the IT industry. Cloud computing is being used widely in IT companies. It provides various benefits to the users like cost savings and ease of use. Because of this benefits the demand for cloud services are increases. Due to this energy consumption in data center increases as well as carbon is emitted in large amount. Therefore, we require to develop some another methodology for environment friendly computing i.e Green Cloud Computing. We proposed our approach toward this.

Keywords: Cloud Computing, Data Center, Energy-Efficiency and Power Consumption, Carbon Emission.

I. INTRODUCTION

The Cloud computing offers lot of applications and services to its user. Cloud computing is solution for addressing challenges such as licensing, distribution, configuration and operation of enterprise applications associated with the traditional IT infrastructures, software sales and deployment models [1]. The cloud computing has made great change in the Information and Communication Technology (ICT) industry by providing services like on-demand provisioning of computing resources which is based on a pay-as-you-go basis [2].

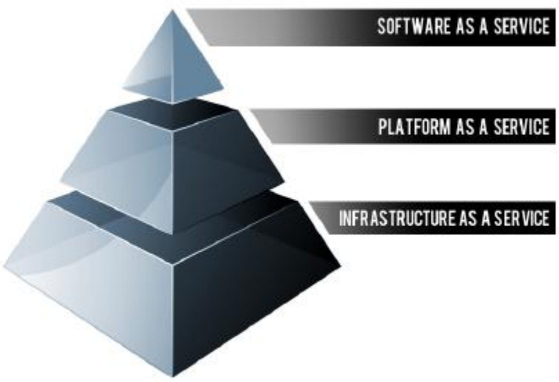

Fig. 1.1 Cloud Computing Service Models [13]

The cloud computing divided into three types of service models:

A. Software as a Service (SaaS):
SaaS cloud provides software services to its end users. The applications are provided to the customers that are accessible anytime and from anywhere. No need to install anything to the customers. The product type of SaaS is web applications and services. The cloud infrastructure including network, servers, operating systems, storage, or even individual application, with the configuration settings are not manage or control by the customers [4][17].

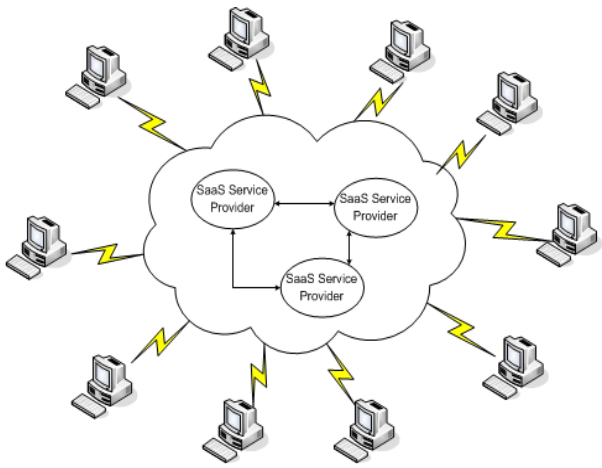

Fig. 1.2 Software as a Service Model [13]

II. PLATFORM AS A SERVICE (PAAS):

PaaS Clouds provide application development, deployment tools and execution management services. The platform for developing applications is provided to the customer. The applications are hosted in the cloud. The core functionality of the middleware is application management. The cloud infrastructure including network, servers, operating systems, or storage are not manage or control by the consumers, but has control over the deployed applications and possibly configuration settings for the application-hosting environment [4][17].

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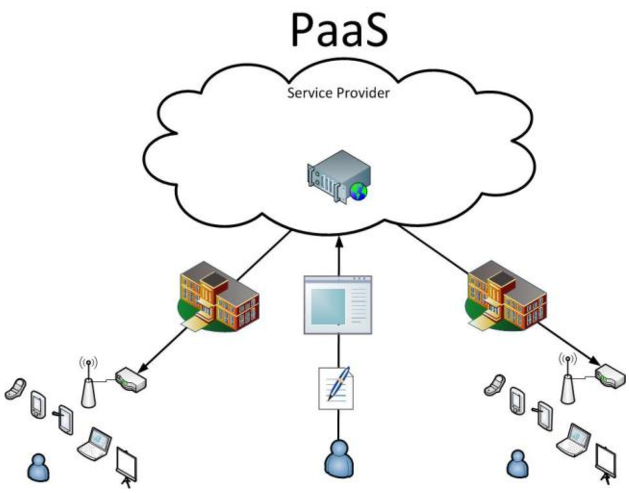

Fig. 1.3 Platform as a Service Model [13]

III.INFRASTRUCTURE AS A SERVICE (IAAS)

IaaS Clouds provide a virtual computing environment, where computing capacity is delivered by assigning Virtual Machines (VMs) to IaaS users on demand. The virtualized hardware and storage is provided to the customers on top which they can build their own infrastructure. The hardware virtualization is best technology for the deliver and implements these solutions. The consumer has control over operating systems, storage, and deployed applications; and limited control of select networking components (e.g., host firewalls) but cloud infrastructure is not manage or control by the consumer[4][17].

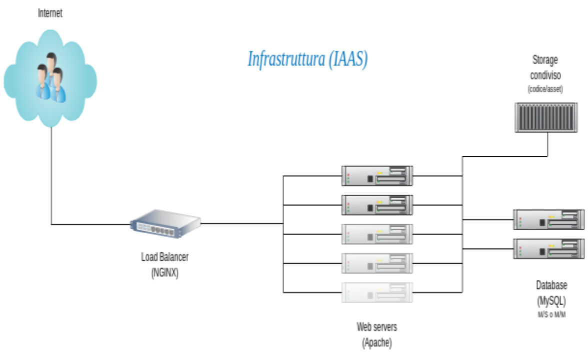

Fig. 1.4 Infrastructure as a Service Model [13]

Cloud computing is rapidly moving target. New technological advances and applications services are regularly introduced. There exist many open challenges especially in the context of energy-efficient management of Data Centers and marketplace for cloud computing [4]. The variety of applications ranging from those that take few seconds for run (e.g. serving request of Web applications such as ecommerce and social network portals) to those that take longer periods of time for run (e.g. simulations or large dataset processing) on shared hardware platform which are operating under Cloud computing model. The challenges like on-demand resources provisioning and allocation in response to workloads are created by the multiple applications in a data center. Therefore there is need to manage those applications. The resources are allocated statically in response to applications in data centers, based on peak load characteristics, in order to provide good performance and maintain isolation [5] [19].

The maintenance of Data centers is expensive and it is unfriendly to the environment. Carbon emission of Argentina and Netherlands is less than carbon emission due to data centers in world [19]. In data centers for power and cool the servers hosted the large amount of electricity needed due to this high energy cost and huge carbon footprints are produced. The profit margin of Cloud services providers is not reduced due to high energy costs because they adopt measures. The data centers of companies such as Google, Microsoft, and Yahoo in barren desert land surrounding the Columbia River, USA for use of cheap hydroelectric power. The Government gives pressure to reduce carbon footprints, which is effected on climate. To solve these problems, leading IT vendors have recently formed a global consortium, called The Green Grid, for energy efficiency of data centers and minimize their effect on the environmental. According to Pike research, data centers energy expenditures will reduce from $23.3 billion in 2010 to $16.0 billion in2020, as well as causing a 28 percent reduction in GHG (green house gas) emission from 2010 levels as a result of adoption of Cloud computing model in delivering IT services [5].

IV.RELATED WORK

A. Existing Work

The work related to the VM placement algorithm in distributed data centers using different carbon footprint rates and PUEs is done. They performed simulations which extends CloudSim and used energy and carbon-efficient (ECE) VM placement algorithm which reduce more power consumption and carbon footprint in ecosystem as compared to previously defined algorithms [3]. Already proposed energy efficient resource allocation solutions for various computing system cannot be implemented for green cloud computing. The main goal of this paper is to get better possible approach towards the utilization of computing resources as well as to reduce energy consumption independent of quality of service [6].

In case of datacenter, the major part of the power is used for other purposes than actual IT services. The four key factors that have enabled the cloud computing to lower the energy usage and carbon emission are Dynamic provisioning, multi tenancy, server utilization, data center efficiency [7]. The 2% of world's total CO2 emission is caused due to the ICT industry and this industry consumes about 8% of world's total electricity. Low carbon routing algorithm is focused on how to dynamically route on demand circuit that is established to transfer energy. The

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30% in carbon emission can be achieved using this algorithm compared to other baseline shortest path routing strategies [3] [8]. A lot of research has been done in power efficient resource management in data centers, e.g. [20] [21].

ICT consumes lot of energy. Major part of this energy is consumed by data centers [9]. Energy efficiency and CO2 reduction within the cloud infrastructure implies that:

- Execution of applications requires less energy, and
- Energy consumed during the execution comes from renewable sources or low CO2 emitting sources [10].

Existing Algorithm:
1. Energy and Carbon-Efficient (ECE) VM Placement Algorithm [3].
2. Carbon Efficient VM Placement and Migration Technique (CEPM) [12].
3. Low carbon routing Algorithm [8].
4. Power Aware Best Fit Decreasing (PABFD) algorithm [14].
5. The Best Fit Decreasing (BFD) VM placement algorithm [16].
6. Banker's Algorithm and Stochastic Integer Programming (BASIP) algorithm [24].

Conventional Algorithms are as follow:
1. Round Robin
2. DVFS (Dynamic Voltage Frequency Scaling)

B. Overview on Proposed Work
Proposed Approach:
Efficient VM Placement for Reducing Energy Consumption and Carbon Emission Approach (EVPRECCE)

Step 1: According to VM request finding the nearest data center.
The VM request comes from the client for deploying their application using cloud services. Nearest data center can be found by their location.
Step 2: After finding data center, check whether host is overloaded or under loaded.
According to condition of host next step will be implemented.
Step 3: If host is under loaded then transferring all VM's to another active host.
Selecting which host is capable of deploying that VM's. Keep under loaded host on sleep mode.
Step 4: If host is overloaded then find which VM's should be transferred.
After that selecting appropriate existing host within data center. Then deploy the VM.
Step 5: Check that host is available to active or not within data center.
If host is available then make it active. If host is not available then find another nearest Data center. Repeat step 2, 3 and 4.

We will use CloudSim for our proposed approach. CloudSim is a tool which contains it's in build classes and packages [22]. It will be used for implementation of project related to Cloud Computing. It contains packages which has the source code, jars, examples as well as API documentation.

Functionalities of CloudSim are:
It supports for modelling as well as simulation of:

- Huge Data Centers in Cloud Computing,
- Virtualized server hosts, with customizable policies for provisioning host resources to virtual machines,
- Energy-aware computational resources,
- data center network topologies and message-passing applications,

It also supports for:
- user-defined policies for allocation of hosts to virtual machines,
- Policies for allocation of host resources to virtual machines [23].

CloudReports is a tool which will be used to create GUI of programming as it is a graphical tool. It is useful for displaying power consumption in graphical manner. Based on the Cloud computing paradigm, CloudReports simulates distributed computing environments. It uses CloudSim as its simulation engine. It provides not only an easy-to-use user interface but also report generation features [13].

Formula for Calculating PUE Factor and Carbon Footprint

$$PUE_i = \frac{Datacenter_i Total\ Power\ Consumption}{Datacenter_i IT\ devices\ Power\ Consumption}$$

$$Total\ CF = \sum_{t=1}^{T}\sum_{i=1}^{dt}(PUE_i \times \sum_{j=1}^{cl}(cf_j \times \sum_{k=1}^{hst}(P(vm_{(i,j,k,t)}) \times ht)))$$
[3]

Table.2.2.1 Symbol and Description

Symbol	Description
PUE	Power Usage Effectiveness
Total CF	Cloud total carbon footprint
dt	Number of data center sites
cl	Number of clusters at each data center
cf	Data center/ cluster carbon footprint rate
hst	Number of hosts at each cluster
P	Proportional power
ht	Virtual Machine holding time

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V. OVERALL SETUP

As larger servers as well as disks are required to process them fast enough within the given time period and due to quick growth of data and computing applications, the issue of reducing the energy usage within data centers is becoming complex and challenging task.

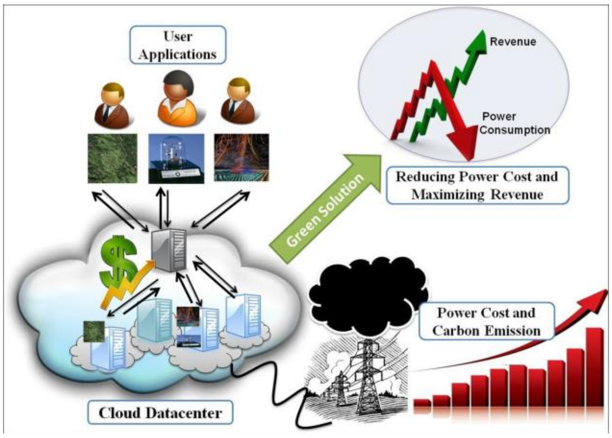

Fig.3.1 Green Cloud Computing Scenario [5][11][18]

To ensure the sustainable future growth of cloud computing, Green Cloud computing is envisioned which accomplishes utilization of computing infrastructure, efficient processing as well as minimizing energy consumption [5]. The resources of the data center need to be managed efficiently to address the problem of massive growth of energy usage. Cloud resources need to be allocated to reduce energy usage as well as to satisfy QoS that is Quality of Service requirements which are specified by users through SLAs that is Service Level Agreements. For achieving the acceptance of user requests market-based utility models are applied. This can be fulfilled to improve revenue along with energy-efficient utilization of Cloud infrastructure [5].

VI. CONCLUSION AND FUTURE WORK

This paper states the problem of energy consumption and carbon emission in distributed cloud datacenters. Overall study on existing methodology is discussed. Cloud computing services are increases because of that amount of energy used by data centers is increases. Therefore, the interest in reducing energy consumption and carbon emission is increases. The cloud providers must implement energy and carbon efficient techniques for improving QoS. We have planned to implementation our proposed algorithm in future.

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