https://dx.doi.org/10.22161/ijaers.4.1.12 ISSN: 2349-6495(P) | 2456-1908(O)

Green Approach for Next Generation Computing: A Survey

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Abstract— *In the past few years, the Information and Communication Technology sector have made a significant advancement in Cloud Computing technology. The world wide acceptance of Cloud technology can be credited to the various benefits a Cloud offers to its users. The Cloud technology helps in preventing resource wastage to a much greater extent. The authors of this paper wish to explore the concept behind cloud computing, its strategy, and benefits. This paper presents some facts and figures related to cloud and green computing which will help in obtaining the gist of Cloud Computing and in understanding the need of going green in computing.*

Keywords— Cloud, Iaas, Paas, Software Quality Assurance, Computing.

I. INTRODUCTION

With the significant advances in Information and Communications Technology (ICT) over the last half century, there is an increasingly perceived vision that computing will one day be the 5th utility (after water, electricity, gas, and telephony). This computing utility, like all other four existing utilities, will provide the basic level of computing service that is considered essential to meet the everyday needs of the general community [1].

II. CLOUD COMPUTING

Cloud computing is a computational model for ubiquitous and on-demand network access to as hared pool of computing resources (e.g., Web server, file server, network resources, data storage, services and applications) which can be quickly provided and released with minimum service provider interaction [2]. This cloud model is composed of five essential characteristics, three service models, and four deployment models. In order to support the maximum number of user and elastic service with the minimum resource, the Internet service provider invented the cloud computing.

A. CLOUD COMPUTING STRATEGY

Within the past few years, the emerging cloud computing technology has become the hottest technology. There are various reasons for the rapid growth and acceptance of this technology. Some of the reasons [3] behind this include the following essential characteristics of cloud computing:

i) On-demand self-service. Users can unilaterally avail the computing capabilities, such as server time and network storage, as and when needed, automatically without requiring human interaction with each service provider.

ii) Broad network access. Capabilities available over the network can be accessed easily through standard mechanisms that promote their use through a heterogeneous thin client or thick client platforms (e.g., mobile phones, laptops, tablets, and workstations).

iii) Resource pooling. The various computing resources of service providers are pooled in a cloud to serve multiple users using a multi-tenant model, having different physical and virtual resources that are dynamically assigned and reassigned according to the user demand. It involves a sense of location independence as the customer generally has no control or knowledge about the exact location of the resources provided but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter). Resources may include memory, storage, processing, network bandwidth, etc.

iv) Rapid elasticity. Resources and services can be elastically acquired and released, in some cases automatically, to scale rapidly inward and outward corresponding with the demand. For any user, the resources available for provisioning often appear to be unlimited and can be acquired in any quantity at any time.

v) Measured service. Cloud technology provides automatic control and optimization of resources used by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be controlled, monitored, and reported, providing transparency for both the provider and the user of the availed service.

https://dx.doi.org/10.22161/ijaers.4.1.12 *ISSN: 2349-6495(P) | 2456-1908(O)*

B. PRELIMINARIES

Virtualization: - Virtualization has become a fundamental and important element of Cloud computing. Virtualization can be applied to a variety of resources such as hardware, runtime environments, storage, and networking, etc. Cloud computing systems utilize hardware and programming language virtualization, server consolidation and virtual machine migration techniques. Hardware virtualization is applied for solutions in the Infrastructure-as-a-Service (IaaS) market segment. Programming language virtualization is a technology used in Platform-as-a-Service (PaaS).Virtualization is one of the most effective tools for more cost-effective, greener-energy efficient computing where each server is divided into multiple virtual machines that run different applications and in this way companies can increase their server utilization rates. This approach is so energy friendly that California utility PG&E offers rebates of $300 to $600 for each server that companies eliminates using Sun or VMware virtualization products, with a maximum rebate of $4 million or 50% of the project's cost, whichever is less [4].

Desktop virtualization: It involves running two or more logical computers on just one set of physical hardware. Besides saving the cost of multiple computers, this technology also reduces carbon footprint generated because of the manufacturing and usage of multiple computer systems. In virtualization, one physical server hosts multiple virtual servers. Virtualization enables data centers to strengthen their physical server infrastructure by hosting multiple virtual servers on a smaller number of more powerful servers, which consume less amount of electricity and thus simplifying the data center. Along with getting much better hardware usage, virtualization also reduces data center floor space, thus making better use of computing power, and greatly reducing the data center's energy demands [5].

Data center:-The significant amount of energy usage in data centers is a big issue for IT professionals. Keeping in view the environmental, financial and operational perspectives, it is important to find a way of reducing the amount of electricity consumed in data centers without compromising the performance. If some appropriate measures are not taken, then the carbon footprint and the IT bill will explode and the energy suppliers may find it difficult to satisfy the increasing demand in energy for data centers [6]. Recommendations have been made by the European Union in a document named "Code of Conduct on Data centers Energy Efficiency" which is a good reference for data centers operators and owners [7].

Also, the Green Grid consortium is a remarkable initiative. The Green Grid is a global consortium of companies dedicated towards developing and promoting standards, measurement methods, processes and new technologies that lead to energy efficiency in data centers [8].

C. GREEN COMPUTING

The current computing is not very environment-friendly. It is assumed that by switching from paper to electronic mode of communications, we are going green‖, and that in doing so we have saved paper and thus done a bit to save the environment and also generate less Carbon Dioxide. But the fact is not as truer as we are led to believe [9]. Each computer requires approximately 1.8 ton of water, chemicals and fossil fuels for its manufacturing. According to a research, computers generate an estimated 35 million ton of carbon dioxide into the atmosphere each year. The CO_2 emissions generated by computers account for 2 percent of world's total CO_2 emissions, almost equal to that contributed by the aviation industry [10].

Manufacturing computers and their various electronic and non-electronic components consume electricity, raw materials, chemicals, and water, and generate hazardous waste. All these directly or indirectly increase carbon dioxide emissions and impact the environment. Each PC in use generates about a ton of carbon dioxide every year [11].

Green Computing, or Green IT, is the practice of implementing policies and procedures that improve the efficiency of computing resources in such a way as to reduce the energy consumption and environmental impact of their utilization [12].

The three main reasons that made us realize the need for going green are [13]:

1. The release of harmful gasses from electronics.
2. More utilization of power and money.
3. The increase of E-waste and improper standalone pc's disposals.

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Fig.1: Landfills due improper disposal of computers.

Green Computing is beneficial as it will [14]:-

- Reduce energy consumption of computing resources during peak operation
- Save energy during idle operation
- Use eco-friendly sources of energy
- Reduce harmful effects of computing resources
- Reduce computing wastes

The following table shows the various Green IT initiatives adopted by three organizations and the benefits they have realized by using them.

Table.1: Few Green IT initiatives and benefits (Source: Infosys Research [15])

Name of the organization	**Green IT initiatives**	**Benefits realized**
CSC	NightWatchman software to automatically power off desktop PCs during non-working hours	• 25 million KWHs of electricity saved per year • 23 kilo-tons of CO_2 emissions eliminated
VistaPrint	Used virtual servers to reduce servers' energy consumption	• Replacing blade servers in data centers with virtual servers' resulted in 75% reduction in energy usage • Saving of 450k USD annually
Huntsville Hospital	VMware virtual desktop Infrastructure for desktop PC manageability	• Virtual desktop-based infrastructure helped to secure HIPAA-regulated patient information in a hosted data center • 72% reduction in power costs to run desktop environment due to thin client architecture • Desktop provisioning time reduced to 15 minutes

PUE, CUE:-Power usage effectiveness (PUE) is a metric used to determine the energy efficiency of a data center. PUE is determined by dividing the amount of power entering a data center by the power used to run the computer infrastructure within it. PUE is therefore expressed as a ratio, with overall efficiency improving as the quotient decreases toward [1]. PUE was created by members of the Green Grid, an industry group focused on data center energy efficiency. An ideal PUE is 1.0 although a typical data center probably has an average PUE of 2.5 (meaning that, for every 2.5 watts of power supplied to the facility, only one watt is delivered to the ICT load).

Carbon usage effectiveness (CUE) is a metric for measuring the carbon gas a data center emits on a daily basis. This metric was also developed by the non-profit consortium, the larger data center managers can calculate CUE by dividing

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the total carbon dioxide emission equivalents (CO_2eq) of the facility's energy consumption by the total IT energy consumption. The output is measured in kilograms of carbon dioxide per kilowatt-hour. The perfect CUE score is 0.0, meaning that no carbon use is associated with the data center's operations.

The rising cost of energy, in addition to environmental concerns, has inspired organizations to seek ways to lower their greenhouse gas (GHG) emissions and carbon gas emissions in particular. In addition to helping an organization make informed decisions about changes that affect global warming, knowing the carbon usage effectiveness metric can help an organization qualify for green computing financial incentives in some industries.

III. CLOUD-SERVICES ARCHITECTURE

The cloud deployments are mainly categorized into three types:

Public clouds:-In public clouds, the services are available to anyone on the internet and they can avail the services of such clouds in a pay-as-you-go manner. It is the most common deployment model of a cloud. A public cloud can offer the following three services:-

i) **IaaS (Infrastructure as a Service):-**Infrastructure as a service means taking the hardware and going completely virtual (e.g. all servers, networks, storage, and system management, exist in the cloud). In other words, businesses pay a fee (monthly or annually) to run virtual servers, networks, storage from the cloud. This will mitigate the need for a data center, heating, cooling, and maintain hardware at the local level.[6]

ii) **PaaS (Platform as a Service):-**Platform as a service is a cloud computing service, which provides the users with application platforms and databases as a service. [3] Is equivalent to middleware in the traditional (non-cloud computing) delivery of application platforms and databases.

iii) **SaaS (Software as a Service):-**The software-as-a-service (SaaS) service-model involves the cloud provider installing and maintaining software in the cloud and users running the software on their cloud clients over the Internet (or Intranet). The users' client machines require no installation of any application-specific software - cloud applications run on the server (in the cloud) [17].

Private clouds:-A private cloud is deployed within an organization's premise in order to provide IT services to its users only. Private clouds impose some limitations on end user applications such as the inability to scale elastically on-demand, greater control over the infrastructure in order to improve security and service resilience due to restricted access.

Hybrid clouds:-Hybrid clouds are deployed by the organizations to provide the advantages of both public and private clouds. In this model, organizations outsource non-critical data and processing to the public cloud, while keeping the critical services and data under their control in their private cloud.

(i) Scheduling in cloud:- Cloud computing has a variety of characteristics such as commercialization, Virtualization, Shared infrastructure, Dynamic Provisioning, Network access, Managed Metering, Self-service based usage mode, self-managed platform, Consumption-based billing, Resource pooling, Rapid elasticity and Multi Tenacity [18]. As Cloud computing is in the developing stage, researchers are interested in areas of Resource allocation and scheduling.

(ii) Types of Scheduling:-[19] The following types of scheduling have been known to exist in clouds. The on-demand service of cloud calls for the need of new scheduling strategies combined with the existing scheduling concepts having some new scheduling parameters in order to provide more efficient scheduling.

a) *QoS based Scheduling*
b) *Online Scheduling*
c) *Resource Scheduling*
d) *Cost-effective scheduling*
e) *Workflow scheduling*
f) *Load balancing*
g) *Capacity planning*
h) *Bandwidth-aware scheduling*
i) *Energy-aware scheduling*
j) *Gang scheduling*

IV. CONCLUSION

The economic and social benefits provided by cloud computing are bound to make it the basis for next generation computing environment. The paper has illustrated the essential characteristics and preliminaries involved in cloud computing. It is also evident that green computing is an integral part of cloud computing, although there is more scope of implementing green approaches to a cloud environment. The stats available regarding the resource wastage and carbon dioxide emission emphasize the need of greening our computing techniques. As they say

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every bright thing has a dark side too. If technology has proved to be a boon for mankind then it might become a curse for the environment we live in.

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