A Review on Secure and Energy Efficient Approaches for Green Computing

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ABSTRACT
The technology has advanced so fast and has attracted almost all the business organizations to move in single dimension called cloud. Green Cloud Computing (or Green Computing) is the energy-efficient and environment-friendly form of cloud computing. Cloud computing is a rising trend employing the concept of large data centers but suffering from the concerns such as exorbitant heat emissions, superfluous consumption of energy, release of tremendous amounts of injurious compounds and gases like methane, carbon-dioxide, nitrous oxide etc. that cause green-house effect. By overcoming all of the stated issues of cloud computing by the help of virtualization and energy-efficiency, green computing evolved as a better technology to adopt. In this paper, a review of all the techniques and approaches utilized to implement virtualization, security and energy-efficiency in green computing has been done. Additionally, the comparison of all these techniques is provided for better understanding. Thus, this paper encourages green computing for cloud computing, due to its better performance and security reasons, to be implemented by all the businesses that are planning to migrate to cloud.

General Terms
Energy consumption, Load Balancing, Server Consolidation, Environment-friendly computing, Resource utilization, Resource efficient allocation.

Keywords
Green Computing, Green Cloud, Cloud Computing, Energy efficiency, Virtualization.

1. INTRODUCTION

1.1 Green Computing
'Green computing' is defined as the use of computing with the added environment responsibility. This concept includes the energy efficient peripherals, energy efficient processors (CPU's) and servers at various data centers or cloud centers. This also comprises of limited usage of resources and a mechanism for proper 'e-waste' management [2]. It is a step towards eco-friendly and cost-effective usage of power and production technology [5]. The term 'green cloud computing' provides environmentally-beneficial features of cloud computing i.e. high utilization of resources as well as saving on cost of building those computers and simultaneously caring for the environment [4].

As the term suggests, 'green computing' means going green with computers. Green computing works on the principle of increasing the energy-efficiency keeping the power consumption reduced. Green computing is a kind of computing in which designing, manufacturing, usage and disposal of the physical servers and all the associated hardware sub-systems like printers, monitors, storage devices etc. and software subsystems such as networking and communication system etc. more efficiently and effectively without having any impact on the environment [2]. The technical processes adopted by the industries create challenges for the management of the waste but green computing demonstrates how to use resources efficiently and how to reduce the waste [2]. Cloud computing, Virtualization, Green Data Center, Grid computing, Power optimization are the major technologies used in the field of green computing [2].

1.2 Need for Green Computing
Now-a-days, everyone is adopting the use of computer system and IT services as they make life easier and are faster, but their increased use results in greater power consumption that finally becomes the reason for the ejection of the toxic carbon compounds and gases like carbon-dioxide in vast amounts [2]. The computer systems and their peripherals continuously consume power even when idle. In addition, data center need a lot of power for their working and efficient cooling systems. If the required power and cooling capacities will be insufficient, then it will result in loss of the whole of energy. According to the related research studies, most of the data centers don't have sufficient cooling capacity which becomes a major cause of environmental pollution.

1.3 Measures to control power consumption
Various fundamental measures needed to be taken in order to control the consumption of power by the hardware while implementing the technology are as follows:

1.3.1 Cloud computing:
Cloud computing enables one to obtain environmental benefits with the features of virtualization. It also eradicates the need for the user to run high-power PCs as it provides its infrastructure-as-a-service [16].

1.3.2 Virtualization:
Virtualization means using the software to simulate hardware or simulating the physical resources by the help of logical resources. In a data center, a number of virtual servers are employed in place of the stand-alone server systems and hence, improve the efficiency in terms of resource utilization.

1.3.3 Wireless Sensor Network;:
Sensors are employed to measure the temperature in various parts of a data center and provide cooling to each of them accordingly [17].

1.3.4 Lower power hardware:
Computer systems are made up of various hardware components like processor on-board graphics, disk, fan etc.

and if all these components consume less power individually, then the total consumption can be reduced [4].

1.3.5 Recycle:
Recycling the waste or the equipment limits the production of environmental pollution [4].

1.4 Merits of Green Computing:
Various merits of Green Computing are presented as follows:

1.4.1 Climate:
Large amounts of emissions of harmful gases like CO2 cause a negative impact on the climate globally and are considered responsible for the damage to the environment and even contribute to greenhouse effect [5].

1.4.2 *Cost-effective:*
Green computing helps a lot in cost savings by making reductions in energy consumption and that of costs from servers cooling and lighting [5].

1.4.3 Reliable:
As the energy demands are continuously increasing and supply is declining now-a-days, energy efficient system ensures healthy power system by utilizing the resources in an effective way so that the energy resources are available for years to come. Many industries even produce their own electricity that motivates low consumption of power resources [2].

1.5 Approaches for Green Computing:
1.5.1 Green Data Center:
Data centers or computer centers are a setup having a computer system with its associated system like telecommunication system and data storage system. Such data centers need backup power supply, a cooling system and a security system. A 'green data center' may be referred to as a repository of an efficient management of the system with a less power consumed environment [2].

1.5.1.1 Practical requirements for setting up a data centers:
The practical requirements for setting up a data center are presented as follows:

- Provide all-time network connectivity in data center.
- Provide sufficient power to run all the equipment.
- Provision a safe physical location for establishing the server..

1.5.2 Virtualization:
Virtualization may be defined as a technique to create a virtual environment such as a virtual operating system (OS), virtual hardware platform, virtual storage device, or virtual network resources [2]. In simpler terms, virtualization is an efficiency-enhancing method of logically separating the physical resources into multiple instances as well as mapping the incoming requests for various services from several clients received by the virtual instances of the resources to their respective physical resources stored at the backend [12]. Virtualization consists of a system admin that combines the physical systems into virtual machines in the maximal energy conserving manner [4].

1.5.2.1 Features of Virtualization:
Virtualization provides a number of beneficial features that are as follows:

- Virtualization provides the cloud consumer with the capability to execute the specified operating systems, applications or other system services in an independent, logically separate and unique environment mapped with the corresponding physical resources [2].
- Virtualization can be used to implement data centers with a focus on energy efficiency by providing several solutions like server consolidation, energy efficiency measurements live migration, data de-duplications and the green metrics to win over IT inefficiencies in them [5].
- Server consolidation raises the utilization ratio of various servers up to 50% or more, saving huge amounts of energy and reducing carbon-dioxide emissions [5].
- It provides assistance in executing the concept of green data centers so that IT infrastructure does not contribute to the huge amount emissions of green-house gases, abruptly limiting the energy costs and the whole cost of ownership [5].
- Virtualization provides an additional function of logical abstraction, while liberating the system services, applications and also the operating system supporting the prohibition to accessing the hardware [2].
- Virtualization is such a concept that deals with the logically separated instances of physical resources rather than the physical resources themselves. This provision helps in creating applications and making the required instances of an operating system or services portable across various physical computer systems. Thus, this concept can help in running the same applications using multiple operating systems and hardware, managing the IT resources more efficiently and allocating those to different computers effectively [8].

1.5.2.2 Challenges for Virtualization:
Managing the complexity of 'licensing' is the major concern while employing virtualization technique. For example, if a Linux based server offers a virtualized windows server, it must fulfill the specified licensing requirements. Due to this licensing issue, flexibility of virtualization technology and benefits of on-demand virtualization are hampered [2]. Dependency on centralized server and network makes the end users vulnerable to server. The user is capable of operating locally using an outage if user either logs off or reboots the machine [2].

1.5.3 Carbon Aware Green Cloud Architecture:
An architecture that considers the objectives of both users as well as providers while curbing the CO2 emission of Clouds is Carbon Aware Green Cloud Architecture [17].

1.5.3.1 Elements of Carbon Aware Green Cloud Architecture:
Its elements are as follows:

- Provider
- User
- Third Party

1.5.3.2 Objectives of Carbon Aware Green Cloud Architecture:

- To provide a novel Carbon Aware Green Cloud Architecture aiming at reducing the CO2 emissions, without having affected the service performance.
- To provide a Carbon Efficient Green Policy (CEGP) to perform carbon-based scheduling that reduces the carbon footprint of Cloud Computing by 25% in comparison to a standard Cloud resource management system [7].

1.5.4 Cloud Broker, LPT and FPRRT:

Another approach is the 'cloud broker' with the two techniques, one is 'Linear Predicting Technique (LPT)' and the other is 'Flat Period Reservation- Reduced Technique (FPRRT)' used to retrieve a little vital information out of the utilization log and simultaneously improvise the M/M/1 Queuing Theory Prediction Approach (MMQTPA) by the help of faster response time throughout the evolving period and lessen the resources kept reserved in a steady sequenced manner. The cloud simulator CloudSim is modified to evaluate and verify the results of the two improvements of MMQTPA [6].

1.5.5 Resolving CO2 Emissions Problem:

The large quantities of emissions of CO2-like green-house gases from various aviation industries, telecommunication industries, shipping industries, transportation business and manufacturing industries are rising high on a very fast pace, but the emissions from IT are mounting even faster. Reductions accomplished by the use of Green computing in multiple key economic sectors will be five times more than the increase in emissions from the IT sector itself [8].

2. RELATED WORK

Cloud Computing is the foundation of green computing. A 'Cloud' can be defined as a collection of computer resources organized to provide access to a computing function as a utility [11]. Clouds support provisioning for fast access of all its resources available on-demand in a virtualized, dynamic, pay-per-use and scalable manner because of its advantages like: agility, low cost, scalability, device independence and location independence [1]. Cloud computing delivered the various resources as 'services' anytime all over the world. Cloud computing help an end user use all the cloud services by using a mobile app or any web browser while the software and user's data are physically stored on remote data server [2]. In the last few years, the major IT companies like Google, Microsoft, Amazon, IBM etc. are pioneering the field of cloud computing because of the evolving data centers and the parallel computing paradigms [11]. Data centers are those components of cloud computing implementation used mainly to provide support for processing large amounts of data [3].

2.1 Cloud Deployment Models:

There are numerous types of deployment models but the three most important types of cloud deployment models include public, private and hybrid.

2.1.1 Public Cloud:

This type of the cloud models are owned by an organization that sell the cloud services. It provides support for the resource allocation dynamically over the Internet using web applications.

2.1.2 Private Cloud:

This type of the cloud models are available within the company and are managed by the organization. An individual can also create such a cloud and the organization is completely responsible for setting-up, management and maintenance of this cloud.

2.1.3 Hybrid Cloud:

Such a cloud model provides a mix of services of the public and the private cloud. The services that need more security and are more confidential to the organization are kept private and other services are made public and thus, getting the flavors of both the services according to the requirement. Also, the management of the cloud services is done by the public and private cloud providers for the respective services [11].

2.2 Cloud Service Models

As the fact is known to all, cloud always provides various resources as services on-demand dynamically, the three main and basic variants of cloud delivery or service models are as follows:

2.2.1 Software-as-a-Service (SaaS):

SaaS is the type of cloud service provided by the cloud server or vendor that enables its consumers to avail and share software(s) as services as and when required [16].

2.2.2 Platform-as-a-Service (PaaS):

PaaS is the type of cloud service provided by the cloud vendor to enable platform access for clients as services so that they can host their software and applications onto the cloud on their own [16].

2.2.3 Infrastructure-as-a-Service (IaaS):

IaaS may be considered the type of cloud service provided by the cloud vendor that enables the availability of the resources like servers, storage space, bandwidth, and other basic hardware and computing resources as services. Also, it allows its clients (or consumers) to manage the storage, operating systems and connectivity applications [11].

2.3 Cloud Computing Features

Following are some important features of cloud computing:

2.3.1 Scalability:

It can be achieved through server virtualization. The best and most popular example of Cloud computing is Google Apps whose services can be accessed through the browser over the Internet.

2.3.2 Efficiency:

Cloud computing is cheaper than all other computing models. In cloud, there exists no maintenance cost because the clients are always free from the maintenance and management issues with respect to cloud and its resources. So, other names for cloud computing are IT on-demand and Utility Computing.

2.3.3 Pay-As-You-Grow:

Consumers are required to pay the service provider only when and for how much they access their services and need not invest a lot of money or develop a complex and costly

infrastructure. Such a model of computing is known as cloud computing. Cloud means a user can access all the services from anywhere and at any time on-demand [4].

Considering energy efficiency as a factor, a cloud computing data center can be referred to as a large collection of communication and computational resources that are properly managed to convert the energy received into the data transfer or computational work in order to fulfill the requirements specified by the client [11].

2.4 Transition from Cloud Computing To Green Computing:

In today's world, almost all modern and growth-oriented organizations strive to adopt new and efficient technologies like cloud computing, thereby increasing the usage of data centers while its implementation. For this reason, employment of new DCs takes place that consume more energy annually [3]. Due to the excessive adoption of cloud computing, a number of issues arise. Various factors responsible for the transition from cloud to green computing are as follows:

2.4.1 Energy Consumption:

The working of the data centers geographically distributed over a large-scale becomes possible when a huge amount of energy is supplied. This input of energy covers a large portion of the total costs that are incurred in operations of these data centers [15]. With respect to the recent estimations of The Gartner group, this consumed energy is nearly 10% of the total current data center operational expenses (OPEX) that can rise up to 50% or more in the coming several years. An idle server i.e. a server not in use consumes nearly 70% of its peak power and this becomes a major factor of energy inefficiency. According to the Gartner Report, the power consumption by an average data center is so large that it can serve as a power source for nearly 25,000 homes [3].

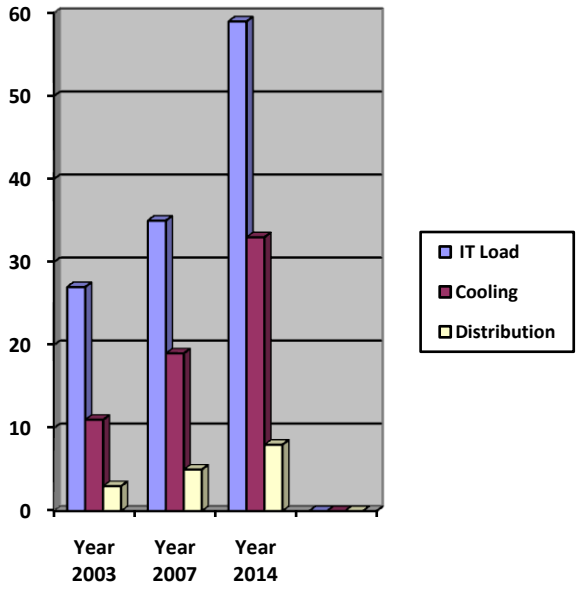

Fig. 1 Energy Consumption Rate in the Data centers

In the above figure (Fig. 1), the rate of increase, with respect to survey done in year 2003, 2007 and 2014, in the energy consumption [19] by the various sectors of the data centers is indicated.

2.4.2 Heat Generation:

The amount of energy consumption in implementing cloud computing has become one of the important contributors to the OPEX bill. Massive amounts of power consumption produce heat and needs to be accompanied with an efficient and cooling system costing a lot like a classical data center costs $2 to $5 million per year. Any failure occurring while the maintenance of temperatures of data centers in between the operational range largely reduce the reliability factor and potentially tend to break the specified and legal agreement called as Service Level Agreement, and SLA for short, signed between the cloud vendor and the customers. Nearly 70% of the heat is produced by the large scale infrastructure used for the implementation of cloud concept [11].

2.4.3 Carbon-Dioxide Emissions:

Another issue is regarding the emitting out of the harmful gases such as CO2. The quantity of the emissions is huge [14] which brings with it its disastrous side-effect named 'global warming' [3].

2.4.4 Security:

Cloud computing still has some security concerns in its adoption [16]. Privacy and integrity is required. The implementation of technology is a success when it is scalable. Also, there should be provision for resource management and a proper network between the users. Now, virtual machines support the concept of multiple users residing on the same machine and sharing the same LAN. So, security risks are high [18]. Also, cloud computing may enable the sharing with hackers in the cloud [4].

In simpler terms, the conclusion comes out from all these factors is that there is a need of modifying the base concept of cloud computing while keeping it eco-friendly as well as energy-efficient without compromising performance in order to minimize all the above issues of cloud computing and Green Computing is such a solution approach.

2.5 Equations

The concept of cloud computing, when implemented, gives out the problems of huge power consumption, excessive heat and ejection of several toxic green-house gases in enormous amounts.

Let cloud computing drawbacks be denoted by ψ and its drawbacks – power consumption be denoted as α, heat as β and green-house gases as χ. Therefore, the equation for drawbacks of cloud computing becomes,

$$\psi = \alpha + \beta + \chi$$

2.6 Achieving Green Computing:

Now, the main activity to be performed for accomplishing Green Computing is to reduce all the wastage of energy by the cloud servers. Following are the ways by which Green Computing can be accomplished or achieved:

2.6.1 According to the vision statement of Intel in 2015, Green Computing also aims to consider the requirement of scheduling the resource allocation dynamically [14]. This initiative taken provides support for saving energy by monitoring the level of load [13] with which the large data centers are running and switching the servers off when idle [12].

2.6.2 To lessen the large quantity of consumed power, the concept of 'virtualization' is employed with cloud computing. Its components are the Virtual Machines, acronymic as VMs and the Servers. These VMs are used to map the two

environments- one is the physical and the other is the virtual and are also used to reduce the hardware. A physical server is mapped to 'n' no. of virtual machines and a data center consists of 'n' no. of physical servers.

2.6.3 Energy can also be saved by mapping a large number of virtual machines with the physical servers [12] with the help of an energy efficient algorithm implementation. Various cloud providers offer service parameters like Quality of Service to their customers and specify it in their legal contract regarding the service provided by them (and received by the consumer) known as Service Level Agreement (SLA). Technically, SLA includes parameters like Mean Time Between Failures (MTBF), Mean Time To Recovery or Mean Time To Repair (MTTR), various data rates, jitter, throughput, or such measurable details to ensure QoS. For such companies performance cannot be compromised and hence, they strive for ensuring performance and minimizing energy consumption at the same time.

2.6.4 The live migration techniques can also prove helpful to well-manage the availability and allocation (and release) of resources effectively within a data center. Energy saving is accomplished by live migration. Various algorithms are available for applying live migration that are based on a simple principle that free all those servers that run on less loads as they consume energy nearly equivalent to the one running on peak load and at the same time, by shifting the VMs from those servers running on lesser loads to the servers running on peak or higher loads. Also, the servers should be kept switch off whenever they are not having any load and are idle [12]. Scaling (either up or down) of the servers dynamically aims for improvising the resource utilization and implementing the technique of load balance [19]. By applying all these ways, energy savings can be increased without affecting the efficient working of the servers. These energy savings play a significant role during different loads.

2.6.5 Now-a-days, researchers working on the issue of energy efficiency focus on optimizing the physical processing components. Also, various physical elements for aggregation, switching and communication links consume, at the least, 30% of the whole computing energy and it actually should be reduced. Likewise, the energy consumed for the communication fabric may also be lessened by limiting operational frequency with the added input voltage for the transceivers and switching elements as well as reducing the communication speeds but this operation of scale-down of the communication fabric should be executed and handled with proper care and it relies on the demands of user applications [15]. Otherwise, the same operation may result in a bottleneck, thereby limiting the overall system performance.

2.6.6 Past studies and research demonstrate that optimizing the architecture of the data center and energy-efficient scheduling for the workloads can positively result in considerable savings of energy [18]. Energy savings up to 75% can be accomplished by different techniques. Traffic managing technique and workload consolidating technique [17] are the two important techniques for saving energy [11].

2.6.7 Green Computing can also be achieved by utilizing the concept of Cloud Brokers. The cloud brokers always try to make complete use of the hardware and retrieve the maximum of profit from the data center. So, this solution technique is discussed which can decrease the consumption of energy by making more effective and efficient use of the hardware and optimize the performance of the system. An efficient resource scheduling and management scheme is the base to performance optimization, an on-demand resource allocation, load balancing and energy saving [19]. The various techniques used for the resource utilization prediction on the basis of which a new cloud resource provisioning scheme are also highlighted to accomplish the target of energy-efficiency [6].

2.6.8 Green Computing may also be achieved by presenting a proposal for a user-oriented architecture 'Carbon Aware Green Cloud Architecture' to decrement the cloud computing's carbon footprint i.e. the limitation of cloud computing of producing carbon-dioxide gas into the atmosphere [17], in an eco-friendly manner without having sacrificed the Quality of Service (QoS) including factors like performance, availability and responsiveness offered by various cloud vendors. This architecture is designed in such a way that it provides incentives to both the users and the vendors to utilize as well as perform the delivery of the Green services. In case of IaaS Clouds, according to the evaluation of researches, huge amounts of CO2 savings can be achieved using Carbon Aware Green Cloud Architecture [7].

3. LITERATURE SURVEY

The several approaches available for implementing the green computing are described as follows:

3.1 Cloud Computing

The foundation approach on the basis of which green computing is implemented is provided by Pushtikant Malviya in 2013, Wei-Tek Tsai and Si-Yuan Jing in 2011 called Cloud Computing. Cloud Computing may be referred to as a rapidly evolving and emerging technology that shares its IT resources among its end users (termed as cloud consumers) as 'services' on demand and on 'pay-as-you-grow' basis. Cloud computing is now-a-days spreading all around the globe and IT giants such as Google, IBM, Amazon, Microsoft and many more have started their cloud computing infrastructure [1]. Cloud provides three kinds of delivery (services) models – SaaS acronymic for Software-as-a-Service, PaaS for Platform-as-a-Service and IaaS for Infrastructure-as-a-Service [16]. All these services are provided through the remote data centers. As the software application and other services are migrated on the remote data center, these data centers must be organized and well-managed [2].

3.2 Virtualization

An approach to implement the Green computing is provided by Anuj Prasher in 2013, Anuj R. Nimje in 2013 and Lena Mashayekhy in 2015 called Virtualization. Virtualization may be defined as a technique of sharing the scarce physical IT resources by mapping them to their logical separations known as instances of the physical IT-resources [12]. The concept of virtualization is one of the two concepts used in the algorithms developed and the other one is 'Energy-efficient scheduling of virtual machines (VMs)' [3]. The paper also discusses the Virtualization technique that provides help in efficient use, saving of energy and a security framework of the Green Cloud which consists of a pool of Virtual Machines (VMs). The security framework mainly includes policy enforcement, trust management and such a security model [4].

3.3 Energy Efficiency

An approach to implement the green computing is provided by Mueen Uddin in 2012, Saurabh Kumar Garg in 2011, Yuxiang Shi in 2011, Chao-Tung Yang in 2011, Jayant Baliga in 2011, Akhil Goyal in 2015 and Chunsheng Zhu in 2015. Energy efficiency has come out to be one of the most important approaches of Green Computing [5]. As the cloud computing is spreading fast, the data centers are becoming

more scalable and consume more energy [15]. There exists an urgent need to develop efficient energy-saving methods [13] to reduce the amount of energy consumption in the cloud data center [6]. Almost all the businesses and companies are investing in developing large data centers to host their cloud services that not only consume large amounts of energy but are also have a complex infrastructure too [7] . The problem is that the provision of these services is quite an energy intensive one, especially if the server is idle or has low utilization and thus, there is a need of improvement in the matter of making the data centers more energy-efficient [19]. Even on very less load like the one involving 10% CPU utilization, the total power consumption is more than 50% of the case when at peak. Hence, an efficient power management approach is proposed with the usage of virtualization technology [8].

3.4 Resolving CO2 Emissions Problem:

An approach to implement the green computing is provided by Chao-Tung Yang in 2011 and Shalabh Agarwal in 2011 to resolve the issue of large-scale emissions of CO2 from data centers into the environment leading to global warming. These gases are emitted out of the various aviation industries, shipping industries, transportation industries, telecommunication industries and manufacturing industries are rising high on a very fast pace, but the emissions from IT are mounting even faster [8]. Reductions accomplished by the use of Green computing in multiple key economic sectors will be five times more than the increase in emissions from the IT sector itself [14].

3.5 Security and Performance Factors:

An approach to implement the green computing is provided by S. C. Rachana in 2011, Si-Yuan Jing in 2011, Arindam Banerjee in 2013, Joanna Kołodziej in 2014 and Kim Khoa Nguyen in 2015. Cloud computing can be considered an emerging and evolving paradigm that redefines the manner the IT-based services may be offered [9]. A serious concern in cloud computing is 'security' which is a big obstacle for the adoption of cloud [16]. The most popular threats of cloud computing are also specified like Loss of control, DOS attacks, Multi-tenancy [17], Availability, Loss of Data, outside attacks, malicious insiders, etc. The solutions to overcome many of these threats have also been provided in this paper [10] [18] in the form of some techniques that are implemented to limit the power utilization without having compromised its performance [9].

4. COMPARISON OF THE GREEN COMPUTING TECHNIQUES

The following tables contain the comparison of all the existing techniques used to implement green computing in terms of their requirements, features, the particular concept on which they are based and their merits as well.

Table 1: Comparison of the various Green Computing Techniques

Techniqu ue	Author & Year	Based On	Features	Merits
Green Data Center	Pushtika nt Malviya and Shailend ra Singh In June 2013	Virtualizat ion and Energy efficiency	Efficient management of the system	Efficient Eco-friendly Less power consumin g

Table 1: (contd.)

Technique	Author & Year	Based On	Features	Merits
Green Informatio n Technolog y (IT)-based framework	Mueen Uddin, Muhamm ad Talha, Azizah Abdul Rahman, Asadullah Shah, Jameel Ahmed Khader and Jamshed Memon In March 2012	Virtualizatio n and Energy efficiency	Distribute the data center components into several resource pools based on energy workloads, consumption ratio and utilization ratio Uses data center effectiveness (DCE) and power usage effectiveness (PUE) and a carbon emission calculator to check the efficiency of a data center	Secure Seamless Eco-friendly Efficient Easy to understand and use
Carbon Aware Green Cloud Architectu re (CAGCA)	Saurabh Kumar Garg, Chee Shin Yeo and Rajkumar Buyya In January 2011	Energy efficiency Environment -based	Address the issue of CO2 emissions. Performs cloud resource management using Carbon Efficient Green Policy (CEGP)	Environme nt-friendly Cost-effective
Cloud Broker, Linear Predictive Technique (LPT), Flat Period Reservatio n-Reduced Technique (FPRRT)	Yuxiang Shi, Xiaohong Jiang and Kejiang Ye In 2011	Analyzing and predicting utilization	Dynamic allocation of resources Retrieve a little useful information from the utilization log Improvise the M/M/1 Queuing Theory Prediction Approach (MMQTPA).	Better response time Less energy consuming

5. DISCUSSION

On the basis of the above comparisons, following points about these techniques come out to be discussed.

- Green Information Technology (IT)-based framework is a comprehensive, easy to understand and use approach that utilizes the concepts of virtualization and energy-efficiency in order to accomplish green or environment-friendly data centers.
- Green Data Center utilizes virtualization and efficient energy consumption to promote green 411computing and additionally, supports more of energy saving by cooling the server as and when it gets overly heated.
- Carbon Aware Green Cloud Architecture (CAGCA) is another attempt towards delivering green services by improvising the energy as well as carbon footprint present in the Cloud Computing and benefits both the service providers as well as the consumers. On the consumer's side, Green broker is used that minimizes the carbon footprint, by the help of a Carbon Efficient Green Policy (CEGP) acting as a scheduler of the applications, while the applications are executed. On the provider's side, specifications and features for the upcoming generation are proposed. This architecture, according to a performance evaluation conducted, is capable of improving the carbon footprint up to 25% while saving up to 23% energy.
- The Linear Predictive Technique (LPT) and Flat Period Reservation-Reduced Technique (FPRRT) are two such efficient and effective techniques that are capable of predicting the resource utilization function and perform the reservations. The former technique i.e. LPT better responds in the continuous increasing period. The latter technique i.e. FPRRT reduces the unnecessary reservation of the resources in flat and smooth period.

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7. CONCLUSION AND FUTURE WORK

Cloud computing has grown so fast that it had made almost every organization rely on it. Since the time it had developed and now there is vast technological change in the field. It requires huge effort to build a technology that could help consumers as well as service providers. Currently, the conservation of energy has risen as a big challenge in the field because due to steep increase in demand the deployment of hardware infrastructure is being done at a faster pace. This infrastructure not only consume electricity by itself it also need auxiliaries which also consumes electricity in order to keep the temperature down for these machines. The amount of energy consumption keeps varying with time and additionally two special cases exist that pose a big problem. The first one is regarding rejection of any task by the data center and the second one is regarding the failure of task on various servers. Thus, numerous efficient and effective techniques can be formulated to reduce the power consumption and implement the different task allocation policies for better utilization of resources in future.

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