Exploration on the energy crisis caused by cloud computing

Arshya Loomba[1], Dhanyashree R Samaga[1], Prithvi B S,[2], Sanjay H S [3], Niranjanamurthy M [4]

[1] Department Of Medical Electronics Engineering, M S Ramaiah Institute of Technology, Bangalore-560054, Karnataka, India
[2] Department of Computer Science Engineering, Jyothy Institute of Technology, Bangalore-560082, Karnataka, India

[3] CloudThat Technologies Pvt Ltd, Bangalore – 560095, Karnataka, India
[4] Departments of AI and ML, BMS Institute of Technology and Management, Bangalore. Pin: 560064. Karnataka, INDIA

arshyaloomba@gmail.com, maildhanyashree@gmail.com, bsprithvi1992@gmail.com, sanjaymurthyhs@gmail.com
Corresponding author: niruhs@gmail.com

Abstract
The on-demand availability of computer system resources, in particular data storage and processing capacity, without direct active administration by the user is known as cloud computing. Since the service provider guarantees prompt, guaranteed, and smooth delivery of our services and also handles all maintenance and management of our IT services in accordance with the service-level agreement, cloud computing removes the need for IT infrastructure upgrades and maintenance (SLA). Switching to sustainable energy sources, such as solar, wind, biogas, water, etc., is the only long-term answer to this issue. For both private and public cloud services, the study showed that computing, storage, and transportation used the most energy. Transportation was even greater energy expenses in public clouds. Equipment for cloud processing has undergone significant energy saving improvements recently. This paper represents the recent trends to prevent cloud computing energy crisis.

Keywords*:* Cloud Computing, Virtualization, Scheduling, Data Centre, Blockchain.

I. INTRODUCTION

Cloud Computing can help change the world and as a technology, it can improve people's lives. However, on the flip side, maintaining a cloud service takes a toll on the environment. The effects of cloud computing, on the environment, can be far more powerful than its merits, if not proceed with caution, and sustainably. In the initial few years of the cloud service only large companies and government organizations stored their data on the cloud and owned data centers, today cloud service is available to every individual at the tap of a button. The basic anatomy of the cloud is nothing but a big computer. The only difference between a traditional data server and a cloud is that instead of localized data servers in each organization, the data is sent to a common database or a unit called a Data

Center. Since most Data Centers are owned by specific service providers, they can focus on one service and make it their niche, which eases the pressure of securing data, off the client organization. A Data Center (DC) is the backbone of cloud-based storage. It is a huge facility that houses thousands of computers, cables, servers, etc. which run on complex algorithms that enable people to access it from anywhere in the world to store, process, and retrieve data.

The past decade has seen a transition from localized storage to cloud-based storage. With the recent pandemic situation, as more people prefer remote working and as data storage requirement has increased, cloud computing has fetched greater demand. The reason is economic efficiency, easy accessibility, upgraded computing hardware, zero server space, better security, and easy data recovery. Cloud computing is an impressive platform wherein a huge volume of data which can be anything like documents, images, videos, etc are stored and processed with high speed, lesser cost, and a pay-per-use concept. For a population of 1.3 Billion people, there are currently 348 cloud service providers and 138 DCs spread across India (as of March 2022).[1],[2] These DCs are about 11 million square feet and 737 MW of IT Capacity. In addition to this land has been acquired for 2,688MW of potential (unplanned) supply has already been taken into consideration for future use.[2]. To cater to the growing market and surge in demand, huge investments are being made in this sector, not only in India but all around the world. The expected growth rate of the cloud computing market (from 2022 to 2028) is a CAGR of 23.9%.[3]

Cloud computing consumes about 1% of the global electricity consumption (Bloomberg) and as more people transition from localized DC to cloud-based DC, this number is expected to rise to 3-8% in the coming decade (Bloomberg). Optimizing and efficient energy utilization is a major issue with cloud computing. These days, cloud data centers are enormous buildings with hundreds of computers, numerous storage racks, complex networks, cables, air conditioning, and the auxiliary equipment required to keep everything functioning. These components release a lot of harmful carbon emissions into the environment. With 5G coming becoming a reality, artificial intelligence and machine learning maturing, increased use of the Internet of Things, real-time video streaming, augmented and virtual reality, and the expansion of FinTech industries the use of cloud computing along with data centers is expected to remain on the increasing trajectory because companies want to tap into new cloud-based solutions as well as increase their current service capability. With the surge in the number of people using cloud services, the load on DCs is expected to increase which would mean a drastic increase in carbon emissions, heat dissipation, power consumption, etc, as well. This makes it a forthcoming crisis. As people have become concerned about the carbon emission of DCs, companies like Amazon, Microsoft, etc have announced plans to reduce their emissions.[9] Service providers are commissioning solar plants to reduce carbon emissions. These planned renewable energy plants come against the backdrop of facilitating digitalization keeping in mind sustainable development. These plants will be commissioned to provide energy to run data centers. According to reports from International Energy Agency, that is around 200 terawatt-hours of electricity, contributing nearly 0.3% of carbon emissions, globally.[10]According to the Paris-based non-profit The Shift Project, Global emissions from cloud computing range from 2.5% to 3.7% of all global greenhouse gas emissions, thereby exceeding emissions from commercial flights (about 2.4%) and other existential activities that fuel our global economy.[6]

II. BACKGROUND

The concept of cloud computing originated in the early 1950s but it gained recognition during the 1990s and 2000s, one of the pioneers being Amazon Web Services (AWS) and Elastic Compute Cloud (EC2). Later few others also joined the club. Cloud computing consists of a few models. The first one is the Service model which comprises three other models which are:
1) Software as a service (SaaS) which offers cloud-based tools and applications for everyday use.2) Platform as a service (PaaS) which allows to create and deploy services and applications for users and 3) Infrastructure as a service (IaaS) which offers essential storage and networking resources. The second model is the Deployment model which includes the public cloud, private cloud, community cloud, and hybrid cloud.

The increased usage of cloud computing has led to high energy consumption and increased costs bringing about a greener approach and a new concept called Green Cloud Computing. Green cloud computing, also called Green IT is an eco-friendly way to minimize power and energy consumption and is geared towards recycling. Green IT has been introduced to convert the cloud into an environmentally safe platform, unlike the general cloud which focuses mainly on the storage and processing of high-volume data. The important features of the Green cloud are virtualization, energy efficiency, multi-tenancy, consolidation, and eco-friendliness. The need for Green Cloud was to reduce carbon footprints and lessen the consumption of power. The principal advantage of Green IT architecture is real-time data execution during which it reduces energy utilization of the internet datacentre and relies upon saving money whilst keeping the planet green.

III. SURVEY OF TECHNIQUES

[10] Gives an introduction to the cloud, the services, and deployment models, Green Cloud along with its origin and its applications are mentioned. The authors have consolidated year-wise studies on 6 papers that show the concerned area of green IT and the objective which have focused to work towards green cloud computing. The need for green IT and the results of the surveys done have been listed along with an elaborated explanation of the area of concern in Green IT and the objectives of energy efficiency and power management methodologies.

Several methods have been proposed to address the problems stated above and reduce the environmental damage caused by cloud computing. The comparative study of green computing areas for the cloud helps us to analyze which one is ahead of the pack and is preferable. The ones which aim towards maximum environmental safety can be chosen. Various studies have been consolidated to make an informed decision as a step towards efficient green cloud computing

Year of Publication	Author Name	Proposal	Advantages	Limitations
2018	Manjinder Kaur	To create a complete system for ranking certification of clouds	The green cloud provider is constructed as a cloud service broker module that analyses consumption information with analytics and offers power management strategies that are energy efficient.	None Identified
2019	Mridul Wadhwa et al.	Energy efficient and power management methodologies.	Comparative study of green IT areas for the cloud.	Active cooling controlling methods not seen.
2019	Archana Patil et al.	To design a comprehensive framework to certify clouds with ranking	Green Cloud Provider (GCP) is designed as a cloud service broker module that analyses the consumption details with analytics and suggests energy-efficient power management solutions.	None Identified
2019	Mohamed Deiab et al.	Energy-aware virtual machine migration for cloud computing	The suggested method offers a different approach for preserving energy efficiency in cloud computing by moving the most heavily loaded virtual machines to the least heavily loaded active machines while	Uses only CloudSim simulator

			maintaining system performance. This is done by performing a live migration of the virtual machines to make sure that no running applications will be disconnected during migration.	
2020	Nayan Agarwal et al.	Proposes rules, regulations, and policies from the government to increase the green revolution in the future.	The technique of improving efficient consumption of resources and e-waste	Implementation of enhancing logical usage of energy not explained
2020	Sharmistha Puthan et al.	Vitally designed resource planning by correct issuing of VMs in cloud datacenter that considers important energy parameter	Discussion of various simulators which provide functionalities to simulate and study the energy aspects in different computing scenarios	Real-time consolidation through the use of virtual machines.
2020	Abdul Aziz Alarifi et al.	A suggested scheduling strategy allocates each request to the best VM that can fulfill it. The servers that will be consolidated and the servers that will host the consolidated servers' virtual machines are then both determined using the proposed consolidation	Architectural configuration of the cloud computing system and the power model of each data center in that system. EEH framework to cope with power consumption problem.	None Identified

		method. The movement of VMs from the consolidated servers is then carried out using a migration algorithm.		
2021	Monali Jumde et al.	Various algorithms address limitations of present VM placement regarding factors like the energy efficiency of servers to initiate the power efficiency.	Clear comparison of various algorithms based on aspects such as energy consumption as well as SLA violation of algorithm	Uses only CloudSim simulator and is restricted to VM consolidation
2021	Robert Karaszewski	Blockchain technology	Better data security, simple traceability, increased system interoperability, decentralization, quicker system discovery, and many other benefits are made possible by the use of blockchain in cloud computing.	Scalability, which results from the time it takes for network users to agree and the time it takes to record transactions in a block, is the main drawback of blockchain technology.
2021	Jai A Mehta et al.	Hardware optimization, which entails lowering energy consumption and making it economically viable; Software optimization, which entails finding ways to boost program, storage, and energy efficiency. Using artificial intelligence	Artificial intelligence is used in cloud computing to control the automation of repetitive tasks. Private and public cloud services are monitored and managed by AI technologies, which transform everyday operations into increasingly complex	The advantages of cloud-based AI technologies can be constrained by poor internet access. Although cloud computing is quicker than conventional computing, there is a latency problem in the cloud that

		to achieve green cloud computing.	independent processes.	delays responses.

IV. APPROACHES

According to Archana Patil and Rekha Patil [11], Clouds are addressing the majority of the problems encountered by today's business organizations, but they are suffering from a few notable limitations - huge power consumption, more CPU idle times, need of deploying the resources at upper bound, emission of carbon gases and producing huge electronic waste (e-waste) material. Henceforth there is a need of developing today's cloud environment as eco-friendly like "Green Cloud Computing". The need for power optimization with multicore CPUs along with secured multi-tenancy architecture with privacy-preserved access to multi-tenancy, has been suggested. [11] Various approaches have been developed and many studies have been undertaken to tackle this issue, some of which have been discussed below:

1. VM Virtualization:

Virtualization is a key piece of technology for the cloud computing environment. In essence, it is a process that permits several users to share a single physical resource or application within a company. Utilizing virtualization technology, cloud computing makes the most of available hardware and software tools. Virtualizing I/O interruptions is one technique to increase operating system performance, where the architecture can also be improved. In yet another paper [11] the authors talk about the virtualization concept uses an abstraction method to enable the operation of multiple virtual computers on a single physical computer. Vincent Motochi, Samuel Barasa, Patrick Owoche, and Franklin Wabwoba (2017) et al. demonstrated how the usage of virtualization techniques reduced the power consumption of the actual computer hardware in their experimental study of cloud virtualization. The authors noted that the power consumption values are affected by the hyper-vision selection process and that launching the appropriate number of virtual machines based on workload also greatly lowers power consumption.

2. Tranquil PCs

There are large volumes of carbon emissions because all data centers adopt cloud computing architecture. The use of Tranquil PCs decreases carbon emissions to roughly 60kg every year when compared to desktop PCs in data centers, which use about 400KW of electricity and even with power-saving measures emit about 270kg of carbon dioxide yearly. Consequently, utilizing peaceful PCs helps reduce carbon emissions. [12]

3. Scheduling algorithms and simulators

Another study focused on how various scheduling algorithms and their loads performed in a green cloud simulation scenario. The operation of the green cloud simulator, a comparison of several simulators, and a comparison of various architectural and algorithm types are all presented. The author has presented a system that builds on the network simulator and adds a green cloud simulator. Because it distributes the most jobs to a smaller number of servers, the green scheduling method uses the least amount of energy of the three. Because it may split up duties among many servers, the round robin algorithm uses more energy than others. The DENS scheduler, however, consistently changes the number of tasks transmitted to the servers. However, it simply discusses the concept of energy consumption through load distribution. Future studies can benefit from implementing this work skillfully along with other power reduction techniques. This broad variety of tests of various algorithms' effectiveness using simulators aids in the move toward green IT. [14]

4. Hardware and Peripherals

There are numerous ways to lower cloud system energy consumption. Intel and AMD both have techniques to reduce power and heat generation, called "SpeedStep" and "PowerNow," respectively. A detailed analysis and discussions on the state-of-the-art software and hardware-based techniques related to energy-efficient resource allocation were carried out and discussed the objective function, policies for resource adaption, methods, and operations for allocation and interoperability. Different energy-saving methods, including servers to support networks and clusters, hardware and scheduling methods, and consolidation tactics, were examined as well.[13]

6. Resource Allocation and Scheduling

The physical machine's dynamic power model and the cloud data center's resource model are both constructed, and then a three-dimensional virtual resource scheduling method (TVRSM) is suggested along with related algorithms. Virtual resource allocation, virtual resource scheduling, and virtual resource optimization are the three processes that make up the virtual resource scheduling process in TVRSM. Three algorithms for TVRSM are created following the aforementioned phases of virtual resource scheduling. These include the multi-dimensional power aware-based virtual resource scheduling algorithm published in the International Journal of Machine Learning and Computing, the heuristic virtual resource allocation algorithm (HVRAA) based on MVBPP, and the virtual resource optimization algorithm (VROA).[15]

7. Nano Data Centre

It is a distributed computing platform. They speak about a huge number of data centers that are lower in size than the typical data centers, which are many but larger in size. The development of nano data centers contributes to a 30% reduction in energy consumption. They are transportable and suitable for usage everywhere, for short-term purposes. With a faster response time, they aid in reducing downtime.

7. Dynamic Voltage and Frequency Scaling (DVFS)

The hardware technique allows processors in physical machines to change their voltage and frequency settings to control how much power is used. Processors in computing nodes must have a capability known as dynamic voltage and frequency scaling to complete this operation (DVFS). In An Analysis Report on Green Cloud Computing Current Trends and Future Research, the author introduced the DVFS (Dynamic Voltage Frequency Scaling) based virtual machines consolidation technique to save energy by running the servers at various voltage frequencies to get over the constraints of the consolidation process live difficulties

8. Migration and VM Consolidation

Experiments using a simulator called CloudSim to analyze the performance of algorithms have been carried out in which a competitive analysis of some algorithms has been discussed. The proposed algorithms also have addressed the limitations of modified Best-Fit decreasing algorithms. However, it uses only the CloudSim simulator and is restricted to VM consolidation. The clear comparison of various algorithms based on aspects such as energy consumption as well as SLA violation of algorithm helps to make a choice The author's experiments help with future applications. As a result, moving toward Green IT is made simpler.

9. Fault tolerance techniques

The ability of a computer system or network to stop any failure or problem is known as fault tolerance. One of the key ideas of fault tolerance is that a system's availability and dependability must be guaranteed. These flaws can be of several types: Equipment faults that are transient, intermittent, or changeless, Operator errors, Software problems, and externally activated failure. Checkpointing, repetition, and replication are the key tools for fault tolerance. Fault tolerance assures that the system will continue to operate even if one or more infrastructure components fail. When a prior component or executable fails, fault tolerance refers to the readiness and dependability of system resources that are unaffected by the failure. A crucial system with high availability is implemented to provide tolerance for the majority of errors. It is not practical to provide a fault-tolerant design for every component, while the accompanying redundancy and over-provisioning have several parasitic consequences, such as an increase in the service's size, weight, cost, power consumption, and creation, validation, and testing times before it is given.

10. EEH Framework

A suggested and assessed energy-efficient hybrid (EEH) framework, aims to increase the effectiveness of electrical energy use in data centers. Both scheduling and consolidation units are part of our architecture. The Sorting Algorithm: Accepts requests and arranges them according to parameters for power consumption and response time. The main goal of this sorting is to reduce the amount of time needed to find the right resource to fulfill the request during scheduling. The Scheduling Algorithm: Receives the requests in their sorted groupings (tasks) and communicates with the central database unit to identify which virtual machines are best suited for each request. The most appropriate virtual machine is the one that has the necessary resources, consumes the least amount of power, and reacts to requests the fastest. The Consolidation Algorithm: Manage underloaded and overloaded server circumstances; specifying the list of virtual machines (VMs) that must be migrated along with the pertinent server requests is the second duty, specifying the list of virtual machines (VMs) that need to be migrated and the related server requests is the last task. The Migration Algorithm: Transfers requests and associated virtual machines (VMs) to new suitable servers. Adaptive values are used for both the lower and upper utilization requirements. According to the patterns of the current server workload, these settings are automatically changed, which takes a lot of load off manual intervention.

11. Blockchain

One of the developments that are now thought to have a bright future is blockchain technology. Blockchain technology enables the unprecedented creation of new programmable ecosystems. It needs to be viewed in a much broader context because it is now only used in the context of safeguarding data access (such as when exchanging cryptocurrencies like Bitcoin or Ethereum). So far, researchers and practitioners have stressed that it offers financial organizations stronger data infrastructures and higher service quality that can be provided more thoroughly and at significantly reduced prices. Additionally, blockchain technology improves security and trustworthiness while supplying a network authentication mechanism.

The efficiency of SSCs can be increased in at least two ways thanks to blockchain technology. It first enables the security of shared service processes and large-scale transactions. Another advantageous element of adopting this technology is that it removes the need for paper documents to be physically produced and delivered: general environmental effectiveness.

V. GRAPHICAL REPRESENTATION

A bar graph is used to represent the energy consumption (in kilowatt-Hour) for 5 methods. As per the quantitative consumption mentioned in each of these cited studies, a bar graph is plotted.

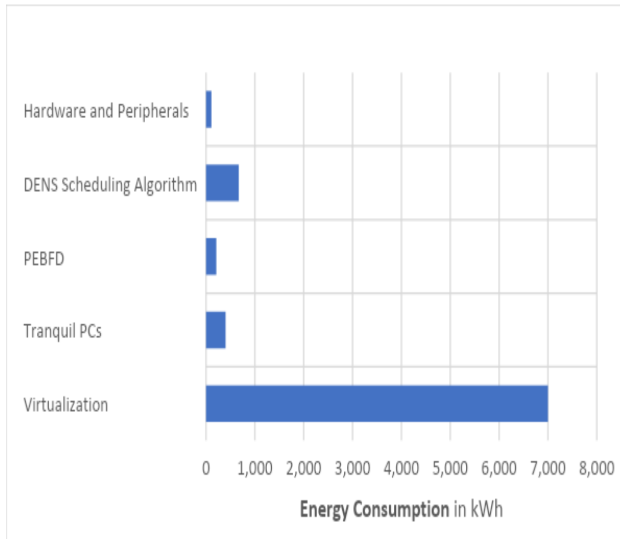

Figure1: Energy Consumption

From the graph it is evident that efficient use of hardware and peripherals results in least energy consumption, whereas Virtualization yields in maximum energy consumption. Refer figure 1.

A bar graph is used to depict carbon emissions (in percentage), when the following methods are deployed.

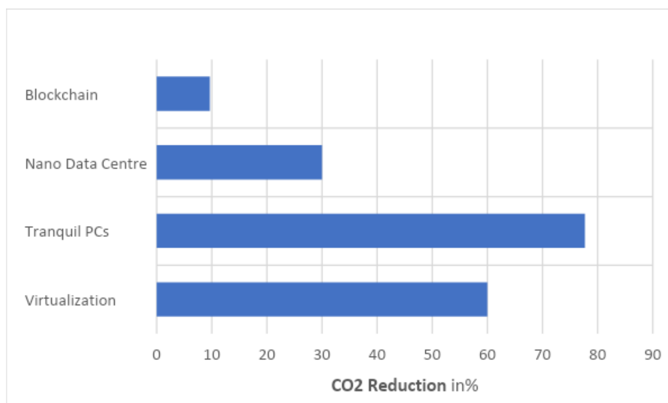

Figure 2: CO2 Reduction.

It is evident that Blockchain method emits least amount of carbon, whereas Tranquil PCs emit maximum carbon, amongst the four methods, according to the data published in previously done studies. Figure 2 represent the CO2 reduction in percentage showing BC, Nano data center, Tranquil PCs and Virtualization.

VI. CONCLUSION

The future Data Center will be propelled by sustainability, fueled by business efficiency, and aided by innovation and green technology. While new technologies and increased digitalization have facilitated social and economic empowerment for people, corporations, and nations alike, they have also placed a duty on everyone to protect the environment in which we live and work.

Different solutions have been proposed to tackle this; the most expeditious solutions involve processing data before it is sent to the cloud. Software and Hardware-based solutions have also come to light. Green Cloud techniques have been adopted by service providers, at different levels and degrees to address these environmental issues. The increasing amount of data, number of users, processing algorithms along with other complexities have triggered a global shift towards sustainable technology. From the given data, we can conclude that employing Blockchain-based and Hardware based solutions seem to be the most-sustainable alternative.

The future challenges include designing novel methodologies with state-of-the-art technologies to optimize the entire lifecycle of the virtualization process, designing the secured multi-tenant architectures and privacy-preserved secured access to multi-tenant modules, design of intelligence support in VM's consolidation, Multi aspect-based threshold value calculation, leveraging the key resources and server downtime management. Hence, the minified guide helps green cloud research scholars to understand the characteristics, present trends, and future research challenges. In this study, the various surveys are discussed, along with their benefits and drawbacks. An annual evaluation of green IT for the cloud is then presented, together with the thoughts and findings of some of the contributors. Additionally, it briefly describes the several methods to green IT which include: the EEH framework, Blockchain, Tranquil PCs, Nano data centers, VM virtualization, etc. After covering several aspects of green IT, this study identifies the main goals on which different studies have concentrated when pursuing green cloud computing. Many areas have previously been researched, but there are still those that need more investigation and development. Green IT aims to save both resources and the environment. E-waste disposal is also anticipated to considerably reduce the risk to human life. Green computing and cloud computing work together to help businesses cut carbon emissions while fostering a productive workplace. Environmental sustainability and green cloud computing are crucial nowadays. Green data centers must become a mandatory requirement for businesses, no longer a 'good-to-have' but a 'must-have'. Embracing green technology to optimize resource utilization and reduce environmental impact, is the key trend for the future of data centers. With more innovation and newer tech solutions, we will continue to move towards becoming a more responsible and efficient industry.

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