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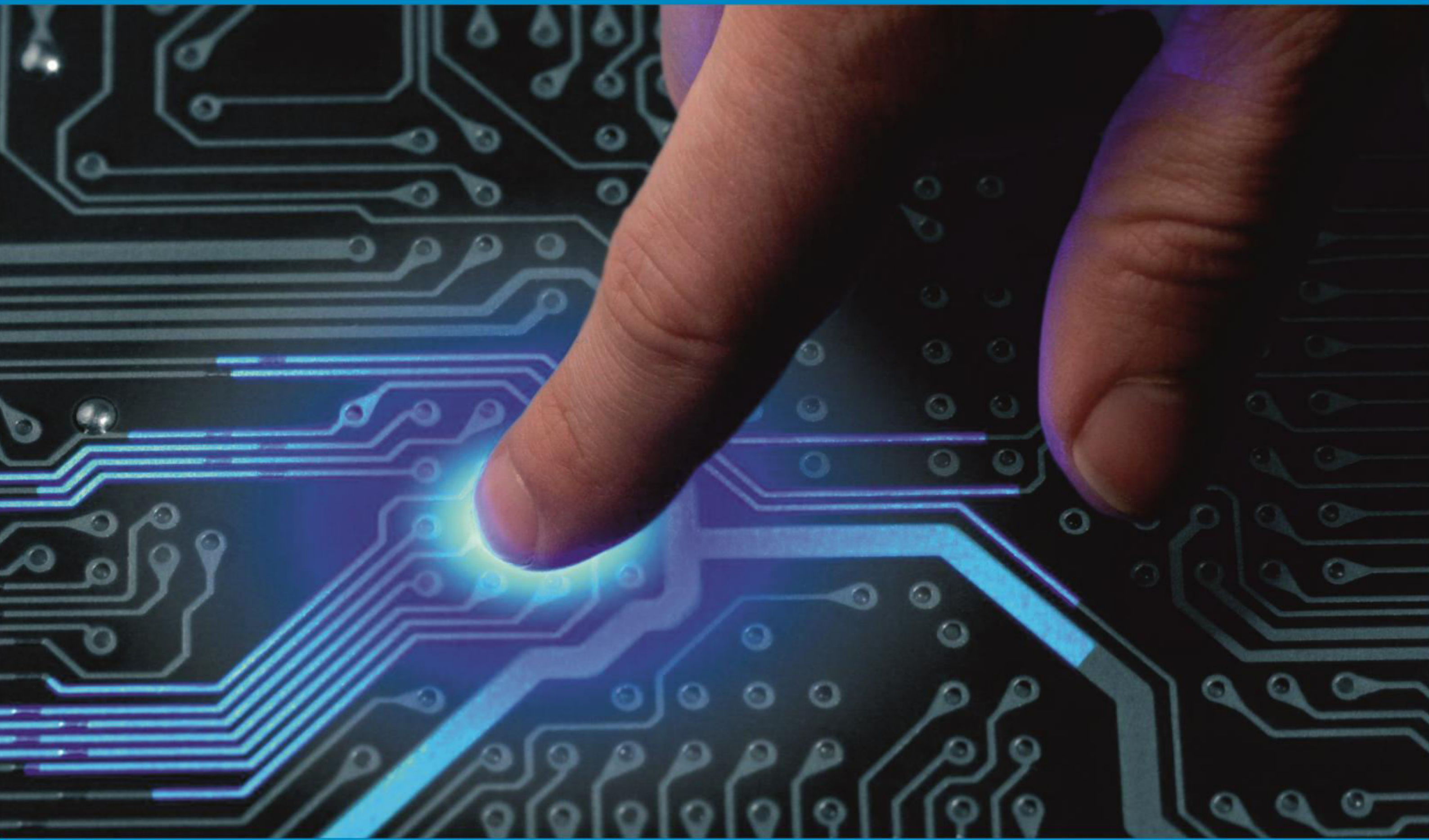

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A Study on Green Cloud Computing

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ABSTRACT: High energy consumption results in significant operational costs, reducing Cloud providers' profit margins, as well as high carbon emissions, which are environmentally unfriendly. As a result, energy-efficient solutions are required to reduce Cloud computing's environmental impact. This provision necessitates the deployment of large data centers that are intimately integrated with the system, resulting in increased energy consumption and CO2 emissions. Since energy has been a major concern in recent years, green cloud computing has become increasingly important, as it provides approaches and algorithms for reducing energy waste through reuse.

Today, cloud computing has become an impressive solution for tackling the challenges of high-volume data storage and process, with low costs and high-speed, on-demand, and pay-per-use characteristics. Although rapid progress has been recorded in the area of cloud computing and its services, attaining the implementation of green clouds is still under development due to a lack of research and several barriers in its implementation. Green clouds are committed to designing as eco-friendly, energy-efficient, max resource utilizable, low carbon emissions, long-lasting, and recyclable. To meet the ever-increasing demands for enterprise data storage and processing, cloud service providers are developing cutting-edge technologies such as Green Cloud Computing in cloud architecture design to reduce massive power consumption, water consumption, the need for physical hardware peripherals, infrastructure, and harmful carbon emissions, among other things. To protect our environment from the negative effects of cloud computing, service providers must switch to Green Computing and update their cloud infrastructure. Green computing researches widely focus on designing efficient clouds with green characteristics like Power Management, High-Performance Computing, Virtualization, Load balancing, Recyclability, Green data center, Reusability, etc. As part of my research on green clouds, this paper presents an analysis report about green cloud computing and its characteristics in a detailed manner. This paper thoroughly discusses the former green computing achievements, current trending concepts of green computing, and future research challenges as well.

KEYWORDS: green cloudcomputing, data center, power consumption, power management, green distributed computing

I. INTRODUCTION

For a decade cloud computing became the popular computation platform for business organizations and helps entrepreneurs to concentrate on their essential business operations instead of investing their time and money in infrastructure management. According to NIST, cloud computing offers various services like IAAS, PAAS, and SAAS, to attract business application owners to adopt and migrate the cloud services to their business app modules. Cloud-based data centers, platforms, servers, and other infrastructure services are enough elastic to supply the sudden demand of huge resources from customers. Most of the software applications like e-mails, messengers, enterprise apps, social web networks, e-cart apps, audio and video streaming apps, broadcasting, and entertainment services are utilizing the cloud services to store, process, and share and secure their data.

The most popular search engine giant Google hosted all of its services like Gmail, Google Earth, Google Drive, Google Play, and YouTube on its cloud platform to offer high-quality services to its worldwide customers. Amazon web services, Microsoft's Azure, Google cloud platform, IBM Cloud are the popular cloud services offering vendors in today's cloud market. At present, Cloud Service has three core service models such as Infrastructure as a Service, Software as a Service, and Platform as a Service. The emergence of Cloud computing is rapidly changing this ownership-based approach to a subscription-oriented approach by providing access to scalable infrastructure and services on-demand. The usage of energy is dramatically increasing in data centers. Effectiveness and Datacentre Efficiency metrics, TDP, etc. PUE is the common parameter. PUE is 1.5 it means that energy consumed by IT equipment is 1kwh, by data center 1.5 kWh and 0.5 WH energy has been wasted as fruitless work like cooling, CPU dissipation, and other work. In many data centers, the value of PUE reached 3.0 or more but by using the correct design

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1.6 values ought to be achievable. This calculation is done in Lawrence Berkley National Labs which illustrates that 22 data centerswith 22 datacentres measured had PUE values in the 1.3 to 3.0 range. , implement the green scheduling algorithm combines with neural network predictors for reducing the energy consumption in cloud computing. In this approach, the server calculates the peak load by predicting the demand from time to the time it takes to restart.
According to the peak load, the number of server states is decided. Let, No is the number of servers in ON state and Nn is the number of necessary servers. If the Nn > No then, choose a server in the OFF state, signal them to restart, and if Nn < No choose server in ON state and signal them to shut down. This system will help to reduce the energy consumption in multiple data centers and results show that it will save 30% of energy. This system is also used to reduce the energy in carbon emissions.

Like Facebook deploys their data centers in Sweden which has a cold and dry climate. There are different hardware technologies like virtualization and software technologies like software efficient algorithms used to decrease the consumption of energy, proposes an energy-aware layer in software –architecture that calculates the energy consumption in data centers and provides services to the users which use energy efficiently, gave cloud computing metrics to make the cloud green in terms of energy efficiency, different energy models have been discussed in this paper to reduce the power consumption and CO_2 emission to make the cloud more green.

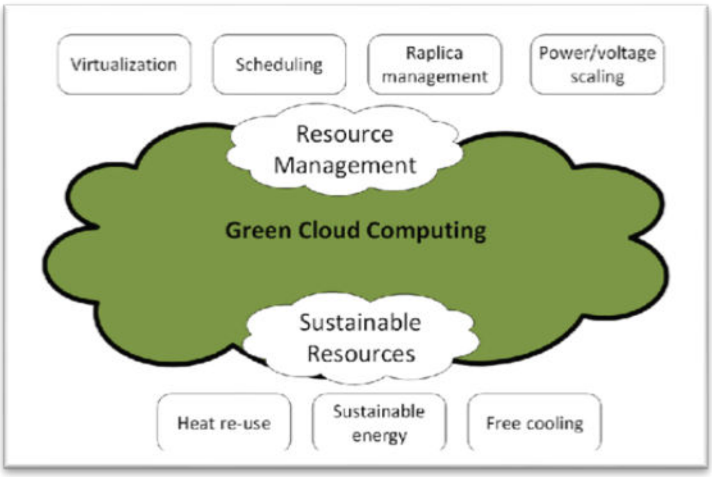

Figure No. 1 Green Cloud Computing Architecture

Packet level simulation of energy has been done through the simulator, like for green cloud NS2 simulator, and found only one existing. The proposed model includes various fields: Data, Analysis, Record, Put on guard, restrain, and virtualization concept in the green cloud to make it energy-efficient and healthy, gave a new challenge in the field of cloud computing, data centers consume a lot of energy, and having energy available at all times is not necessary, so the author discusses solar energy in his paper. How solar energy can play a vital role in data center's energy consumption is a hot topic of discussion.

II. RELATED WORK

As a feature of our examination investigation on "Green Cloud Computing", we completely confirmed numerous diaries, meetings, white papers, web sources to get incredibly substantial substance about green distributed computing and its attributes. In this part, we present the writing survey on green distributed computing with the assistance of its significant previous examination distributions. Every prominent examination movement in the space of green distributed computing is investigated in a word with creator subtleties. This data helps the credulous examination researchers to comprehend the assessment of green distributed computing and the enhancements it has had since the start. Pat Boher et al (Pat Bohrer, Elmootazbellah, et al., 2002) explored ideal force the board strategies while working the web workers at their low degree of usage, with no impact on its exhibition. They considered the framework logs as the principal input sources, to get the energy utilization upsides of a web worker at different degrees of use. They presented an effective force recreation system to screen the CPU and different assets devoured energy esteems, which helps in gauging the future energy necessities. David creeks (D. Streams, M. Martonosi, et al. 2001), planned the

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"Powerful Thermal Management" strategy with CPU level clock gating strategies. This assists with running the fundamental processer with max-low force, yet, the investigations on this strategy saw that it somewhat impacts CPU execution. In 2001, Jeffrey (J. Pursue et. al, 2001) proposed the" energy- cognizant provisioning" strategy, to dispatch the heap of the approaching solicitation to the inactive workers, to save the energy, and to use the assets equitably. This technique spreads a heap of a solicitation equitably on all potential cases to finish the tasks at high velocity (as submitted in SLA). For this situation, the assets are dividing the genuine cycle between them to come out from the underutilization of assets issue. Jonathan G (J.G. Koomey, 2007) directed an examination on USA server farms burning-through power esteems alongside the other computational gadgets burning-through power esteems. With this information, he assessed that by 2005 the force utilization worth of server farms is 0.65% of complete US producing power. John Judge et al (John Judge, Jack P, Anand E, and Sachin Dixit, 2008) distributed a white paper on energy effectiveness, to disclose how to lessen the force utilization of server farms without influencing the worker execution and accessibility. At long last, he recommended that the usage of conceivable low voltage safe processors, arrangement of force the executive's apparatuses (to screen and auto administration of force), virtualization methods (to expand the handling power with same assets), plan of sharp edge workers, and productive cooling instruments are the accepted procedures to plan energy-proficient mists.

Eduardo (Pinheiro Eduardo, Bianchini Ricardo, et al, 2001) distributed an article on carrying out the heap adjusting and unbalancing procedures in bunch-based frameworks, to lessen power utilization and to improve the handling speed. They planned the bunch-based framework with an "on and off system" to robotize the turn on and turn off tasks dependent on the requirement for power. At the worker level and the working framework level, this system was executed and recorded the great outcomes in asset streamlining. Luca Benni et al (L. Benini, A. Bogliolo, and G.D. Micheli, 2000) overviewed framework level plan methods to improve the exhibition of cloud dynamic force the executives (DPM) methodology. As a component of their overview, they completely reconsidered the previous explore on different framework level unique force the executive's strategies. This information assists them with seeing how the current force the executives procedures are working with limits and how the future unique force the board strategies to be intended to accomplish better execution. They depicted the System Component level force the board, System-level force the executives, Network level force the board and they proposed some eminent unique force the executive's procedures exhaustively.

In 2010 Dzmitry (D. Kliazovich, P. Bouvry, Y. Audzevich, and S. U. Khan, 2010) planned NS-2 based test system to record the force utilization at green cloud server farms. He used that test system to run various analyses to record the cloud's force utilization benefits, which included an Intel Xeon 4-center processor, 8MB DDR3 RAM, and a 3.33GHz of store esteem. They re-enacted and observed the workers, switches, connections, switches, and jobs to decide the force utilization at every element level. This recreation climate gathered distinctive cloud parts identified with significant force utilization insights like limit high/low force use esteems at every part, segment inactive state power use, segment normal force use, and so on From their recreations, we saw the diverse cloud segments devouring energy esteems are CPU-130W (43%), Memory – 36W (12%), Disks- 12W (4%), Peripheral-50W (17%), MotherBoard-25W (8%) and others – 48W (16%).

Green Peace International association projected "ICT power utilization and Carbon Emissions by 2020" study report (Green Peace A global article, 2010), determined that both Electricity utilization and Carbon Emissions will record the yearly development rate between 9 - 9.6%.

They illustrated the three key components about the soundness of present mists are I) Clouds are extending yet not aiding the financial development of supplier as anticipated, ii) exceptionally focusing on energy-effective cloud server farms plan, and iii) Popular cloud suppliers are building the limit enormous information focuses to handle the contenders. On the opposite side, this green harmony article is shooting some vital inquiries to the server farm proprietors to help the green IT are High Energy utilizations, Carbon discharges, Energy creation sources (wind, pressure-driven, coal, atomic, and so forth), and proficient asset the board, and so on. After the whole examination on green distributed computing, we told that the significant four mainstays of green mists are energy proficiency, versatile asset the board, low working expenses, and ecological kind disposition.

III. GREEN CLOUD COMPUTING AND ITS CURRENT TRENDS

Green Cloud Computing is a winning situation for both cloud service providers and the environment. Green cloud is beneficial not only to the environment but also lets service providers make more money by maximizing resource use. By applying those management policies and characteristics, we will make current cloud environments green-certified.

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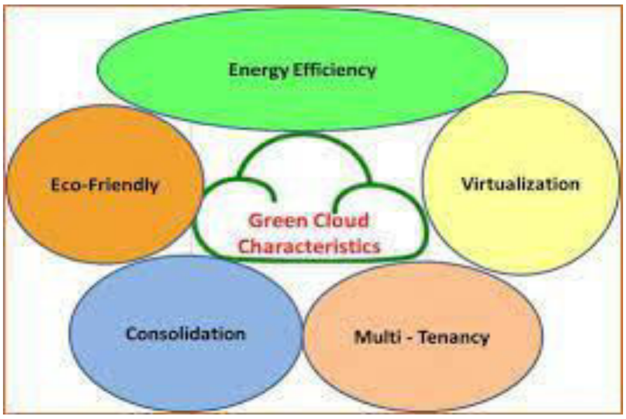

Figure No. 2 Characteristics

I. Energy Efficiency

The word "energy efficiency" is a fundamental component of green cloud computing, and it plays a significant role in the development of environmentally efficient green clouds.

Energy efficiency in the cloud refers to the use of effective power management strategies to reduce power consumption at the cloud object-level like servers, data centers, discs, routers, processors, and so on. Anton Beloglazov published a survey on energy-efficient data centers and cloud computation systems (Anton Beloglazov, Raj Kumar Buyya, Young Choon Lee & Albert Zomaya 2011). In this survey, they described the power consumption sources, power consumption modeling, static and dynamic power consumption methods, and high power consumption problems in detail. They also addressed the taxonomy of power consumption at the hardware, operating system, virtualization, and data center levels, which are the most power-intensive components of cloud computing architecture. In both high and low consumption requirements, the static power management system provides the same voltage of power and switches on all relevant cloud services without knowing the need for them in processing. To avoid the unnecessary use of huge energy in cloud environments, recent researches (L. Benini, A. Bogliolo & G.D. Micheli, 2000 and D. Kliazovich & P. Bouvry, 2010) were proposed dynamic power management (DPM) system. This system only starts the cloud resources that are required at the start, estimates the power requirements, and supplies the appropriate power voltage based on demand. If any cloud resource is supplied with insufficient power (voltage), the problem will be identified and corrected as soon as possible using dynamic power management techniques. This is called the dynamic power optimization process. Current trends in this area include Dynamic Power Management (DPM), work on power utilization monitoring tools, design of power utilization simulators, decision-making algorithms in DPM, component-level power management (resource power optimization), and the creation of mixed work environments.

ii. Virtualization

The virtualization concept is designed to run several logical computers on a single physical computer using the abstraction process. As we know that the concept of virtualization allows the creation of multiple virtual machines to execute a couple of tasks simultaneously. Virtualization is not a new concept in IT; it was already implemented with our grand old Main Frames which belong to second-generation computing devices.

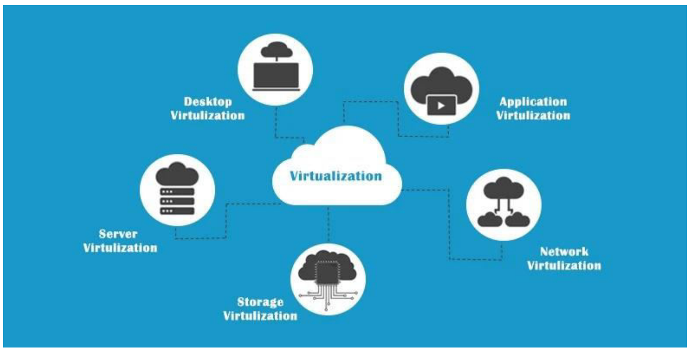

Figure No. 3 Virtualization

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Traditional processing methods will allocate the entire resource set to the running task before they begin.
To overcome the sequential processing limitations, hypervisor-based VM's are designed later to run multiple jobs in parallel on the same machine with resource sharing facilities. Jayabalan Subramanian's article on cloud virtualization assumed that cloud virtualization helps in utilizing the available resources at a high rate and reduces the amount of time requires in performing a unified task, which indirectly causes to save the huge power in cloud lifetime. Vincent Motochi et al shared their experimental analysis on cloud virtualization, to show how virtualization techniques reduced the power consumption of physical computer hardware. High-speed processing, low power consumption, high-end resource utilization, and cost savings are the achievements of virtualization, which help in designing the green clouds a lot.Dynamic workload balancing with VM's, Resource sharing across VM's, design of secured VM's, and energy optimization techniques for virtualization is the trending activities of green clouds.

iii. Multi-Tenancy

Multi-Tenancy means an instance of cloud is servicing multiple tenants of the same category, to avoid the additional investments and utilizing the available resources efficiently. Most of the time, multi-tenancy became a controversial topic in news on the cloud, due to some privacy and security issues involved in its implementation. At the SaaS level, the deployed application resources are shared among multiple tenants, i.e. SaaS contained the line-of-business category applications like Salesforce CRM, which is a single instance but offering its services to several organizations. Each customer belongs to a separate organization but all customers are storing their data in the same database tables offered by the CRM application. From the thorough analysis of the cloud multi-tenancy process, my research noticed that multi-tenancy acquires more profits to the cloud service provider by servicing the multiple applications with a single cloud instance. But most of the service consumers fear to participate in this multi-tenancy environment due to privacy and security phobias.

iv. Consolidation

In Green Cloud Computing the concept consolidation means the process of deploying different data centers related to data processing applications on a single server with virtualization technology. This is the primary sub-task resulting from virtualization, and it is dedicated to implementing process-level load balancing, better virtual system utilization, and reduced power consumption.

	Electricity Consumed in 2007 (Billion KWH)	**Electricity Consumption forecasted for 2020 (Billion KWH)**	**Electricity relevant Carbon Emissions by 2020 (MtCO2e)**
Data Centres	330	1012.02	533
Telecom	293	951.72	501
Total	623	1963.74	1034

Table No. 1

The proposed online deterministic and non-deterministic algorithms explain the process of VM migration in the cloud. In another research paper, they proposed a threshold-based approach for the IaaS platform, to perform the VM's consolidation to balance the load efficiently and to avoid resource underutilization problems. The consolidation process is a resource incentive, and intelligence support is expected to minimize server downtime. To overcome the consolidation process live problems limitations, he proposed DVFS based virtual machine consolidation technique, to save energy by running the servers at different voltage frequencies.

v. Eco-Friendliness

The term green cloud computing implies that the green clouds are environment-friendly clouds, which are specially designed to minimize the environment spoiling activities and ensures the non-disturbance to ecology elements. In this paper, we mostly discussed energy efficiency all the way, because if we save the power means we reduced the need for power production, which helps in regulating the dioxide emissions to the environment. Today's energy sector is highly

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dependent on Coal-based power generation and Nuclear-reactors based power generation systems, which release harmful monoxides to the environment to fulfill our energy needs. With detailed statistics and forecasts, the Green Peace international organization published an article explaining how cloud computing and its components are affecting the environment.

Their statistics provide information about how much carbon is released to the environment to produce enough electricity for cloud object's consumption. They expected that, along with the energy-efficient cloud environment, the executing software application should be aware of the energy efficiency. They thoroughly examined the SDLC process of software development and identified the considerable areas of software applications to design them as environment-friendly.

IV. GREEN CLOUD FUTURE CHALLENGES

• Energy Efficiency:

As today clouds are designing with multi-core CPUs, there is a need of designing power optimization and management techniques to support power management with multi-core CPUs. Another huge power-consuming part of the cloud is the data center, which is a collection of data storage components and data management software. An efficient power consumption monitoring system, dynamic power management system, and intelligent power supply decision-making systems are the research challenges in this area. Given the current state of IT, a comprehensive and intelligent mechanism is required to address the entire cloud architecture level energy optimization issues.

• Virtualization:

Many former types of research were widely concentrated on designing the efficient cloud virtualization process, but virtualization is still suffering from some high-end optimization relevant limitations. A major research challenge is to develop novel methodologies using cutting-edge technologies to optimize the entire lifecycle of the virtualization process. Automated optimal VM creation with substantial resources and dynamic resource allocation & sharing facilities without affecting the cloud performance is the other considerable research challenge in virtualization.

• Multi-Tenancy:

Although this an essential character of green cloud, at present multi-tenancy, is suffering from privacy and security concerns. Designing the secured multi-tenant architectures and privacy-preserved secured access to multi-tenant modules are considerable future research challenges.

• Consolidation:

Design of intelligence support in VM's consolidation, Multi-aspect based threshold value calculation, leveraging the key resources, and server downtime management became the future research challenges in this area.

• Eco-Friendliness:

This area focuses primarily on the development of environment-based tools, such as carbon emission calculators to assess the impact of the cloud on nature. A comprehensive framework for certifying and ranking clouds based on multiple aspects of Green Cloud Computing is required.

V. CONCLUSION

As part of our research analysis on green cloud computing, in this paper, we presented the literature review on green cloud computing. At glance, we briefly explored the concept of cloud computing and the need of designing green clouds. The literature review presented the former scholars conducted researches on green clouds, their research identified limitations and proposed solutions. We went over the green cloud computing architecture and the various modules in great detail. We went over the green cloud computing architecture and the various modules in great detail. This paper mainly focused on exploring the notable characteristics of green cloud computing with past research discussions, present trends, and future research challenges. This paper is designed by authors as a minified guide to green cloud research scholars to understand the green cloud computing characteristics, its current trends, and future research challenges.

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