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EXPLORING THE MODERN ERA OF GREEN CLOUD COMPUTING, STRATEGIES, CHALLENGES AND ITS BENEFICIAL EFFECTS ON ENVIRONMENT

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ABSTRACT

Today it is globally known that mankind is the major reason for global warming. Data Centers, computers, and other electronic gadgets are the leading causes and sources of greenhouse gasses, especially CO2. Data centers use thousands of processors and other computer elements that generate heat which requires a huge amount of cooling equipment, cooling equipment again generate a substantial amount of heat. Thus, we need such ideas and techniques that will reduce the energy consumption and emission of CO2. To protect our environment from these negative impacts, the service providers must adopt and upgrade their cloud infrastructure towards green computing. Green Cloud is an Internet Data Center architecture which aims to decrease data center power consumption, and at the same time guarantee the performance from users' perspective, leveraging live virtual machine migration technology. Green computing researches widely concentrates on designing of efficient clouds with green characteristics like Power Management, Virtualization, Load balancing, Green data center, Reusability, Recyclability etc. Saving energy or reduction of carbon footprints is one of the goals of Green Computing. Green Cloud Architecture also enables complete online monitoring, live virtual machine migration and VM placement optimization.The aim of this paper is a literature study of the challenges and various issues in field of Green Computing, comparing different techniques of green cloud computing and the future scope of Green Clouds.

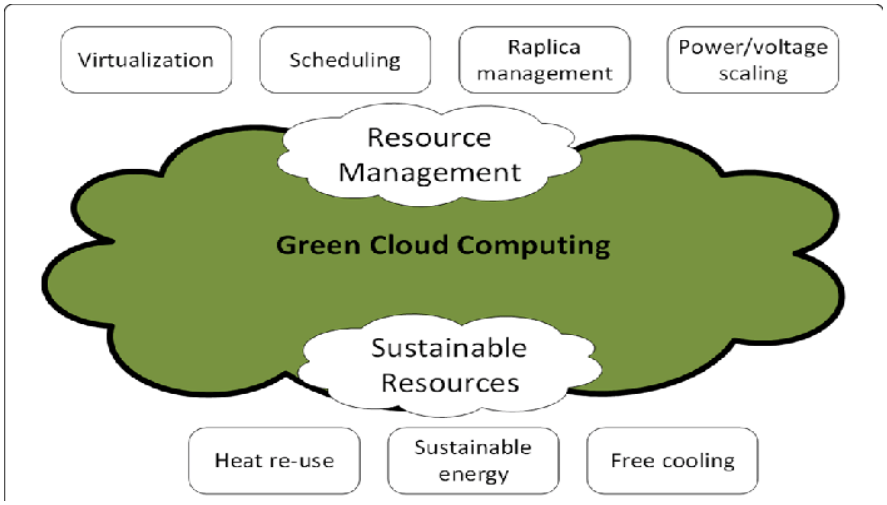

Fig.1) Diagram representing what is Green Cloud Computing

INTRODUCTION

Green computing is making data center and electronic devices environmentally friendly and ecofriendly, in other words, it is described as the inspection of engineering, designing, manufacturing, disposing and using of computing peripherals in such a way that minimizes their environmental brunt. In 1992, the Environmental Protection Agency (EPA) introduced the Energy Star program, it was a very first time when the term Green Computing came into light To see the growing demand for cloud computing in every field it is important for the environment that we take one step ahead towards green computing so that electricity consumption and CO2 emissions can be cut down and recycled. Usually, cloud data centers span in greater than thousands of feet of area that contain ultimate computing power like servers, networking devices, hard disc racks, cooling fans, console, big screens etc. along with cooling machines, air conditioners, lights and backup generators so that they can fulfill their day to day costumer's demands. All these things requires a large amount of power. In 2012 electricity consumption by these data centers was measured around 38 Giga Watts which was sufficient to almost all united kingdom's residential households, as compared to 2011, and it is continuously increasing every passing year . As the demand of Cloud Computing is on peak now a day due to its tremendous capabilities of bringing on-demand services, numerous organizations and companies are migrating towards the cloud and as a result many data centers coming into light.Today only one data center occupies a massive amount of area, 50,000 square feet approx. that needs 5 megawatts (mv) electricity in order to fulfill the need of the power of 5000 households for one year. So now these data centers require cooling also to cool down their giant servers as these servers provide their services and run 24/7 and 365 days continuously without any break, it's true that all servers are not in use all the time but it is

also true that they can't be turned off. According to a recent study only US data centers consumed about 70 billion kilowatt-hours of electricity in 2014 that was 30 billion watts in 2012 all over the world, now we can see that how much these data centers are consuming electricity and discharging CO2 and due to the increased energy demand, the rising economic and environmental costs of data centers are also becoming a real concern.

There are more than three billion active internet users all over world that are continuously surfing the internet through Google, Google runs 1000 servers just for one query, that's why it takes only 0.2 seconds for query results to come up, in a single day sixty million searches hit the Google search engine. Figure 2 and 3 will demonstrate how much CO2 is dissipated and how much electricity is consumed in one Google search as Google data centers consist of thousands of servers, these servers demand huge supply of electricity to working seamlessly, now the consequences come in the form of CO2 emission, thus these data centers are one of the biggest responsible for global warming. So now it is our duty that we find some innovative ways to overcome this problem, it is our responsibility to find such ideas and techniques that help us to reduce electricity consumption and CO2 emission.

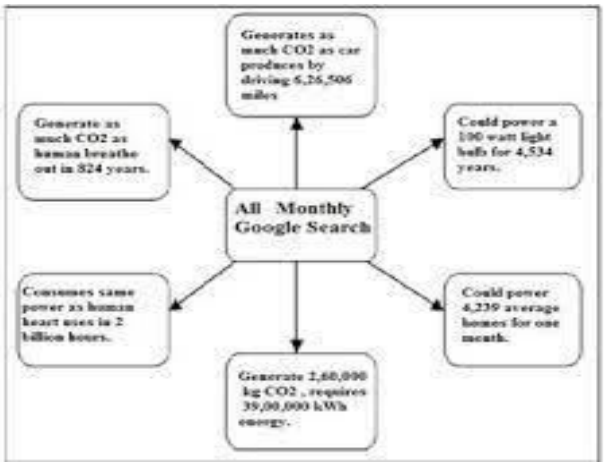

Fig.2)EnergyConsumption in a monthly Google search

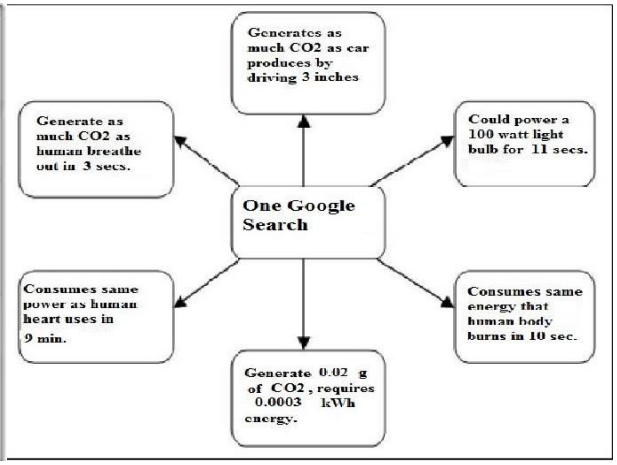

Fig.3) Energy consumption in one Google search

GREEN DATA CENTERS

'Green Data Center's applies to energy-conscious, energy-efficient, and CO2 emissions reducing architectures, protocols, tools, infrastructures, and algorithms in data centers.

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A green data center, or sustainable data center, can be defined as a service facility which utilizes energy-efficient technologies. They do not contain obsolete systems (such as inactive or underused servers), and take benefits of recent, more efficient technologies. Green data centers uses more advanced technologies for implementing data storage, management, and operations on the data.

Green Data Center approach will continue efforts to minimize greenhouse gas emissions and help preserve the environment. Data Center energy is related to carbon emissions and three key factors that affect carbon footprint of a data center are: Location, IT Load and electrical efficiency. A geographical location which experiences extreme temperatures and humidity levels will consume more energy as the data center physical infrastructure systems work harder to maintain consistent, moderate temperature and humidity levels. IT load reflects what proportion of power the IT equipment in the data center consumes. The IT load consists of all of the IT hardware components that build up the IT business architecture: servers, routers, computers, storage devices, telecommunications equipment, and the security systems, fire and monitoring systems that protect them. Loads can go up (due to an increase in processing requirements from the lines of business) or down (due to impact of virtualization or consolidation).

GREEN CLOUD ARCHITECTURE

The Green Cloud Architecture is a kind of flexible architecture having offline configuration and server implemented clones. The Green Cloud Architecture consists of Green Broker that analyses user requirements. It calculates cost and carbon footprint of services and carbon aware scheduling, The Green Offers directory lists services with their discounted prices and green hours and the Carbon Emission Directory contains data on Power Usage, Effectiveness, cooling efficiency, carbon footprint, network cost. It helps user to select cloud services with minimum carbon footprint. The Green Cloud Architecture enables comprehensive online monitoring, live virtual machine migration, and VM placement optimization. The Green Cloud Architecture puts a concern over the structure and the social responsibility of energy consumption so aiming to insure infrastructure sustainability without breaking contracts. Therefore, the Green Cloud architecture reduces unnecessary power consumption during a cloud computing environment. Green Cloud architecture, help consolidate workload and achieve notable energy saving for cloud computing environment, at the same time, also guarantees the real-time performance for many performancesensitive applications. Companies are realizing that the sources andquantity of their energy consumption significantly contributes to greenhouse gas (GHG) emissions. In response to this awareness, companies are currently using the following equation:

Reduced Energy Consumption = Reduced Green House Gas Emissions = Reduced Operational Costs for the data center and business [1]. A typical data center consumes energy in four basic areas: (i) Critical Computational Systems that is servers, network and storage. (ii) Cooling Systems. (iii) Power conversion such as Power Distribution Units and (iv) Hoteling.

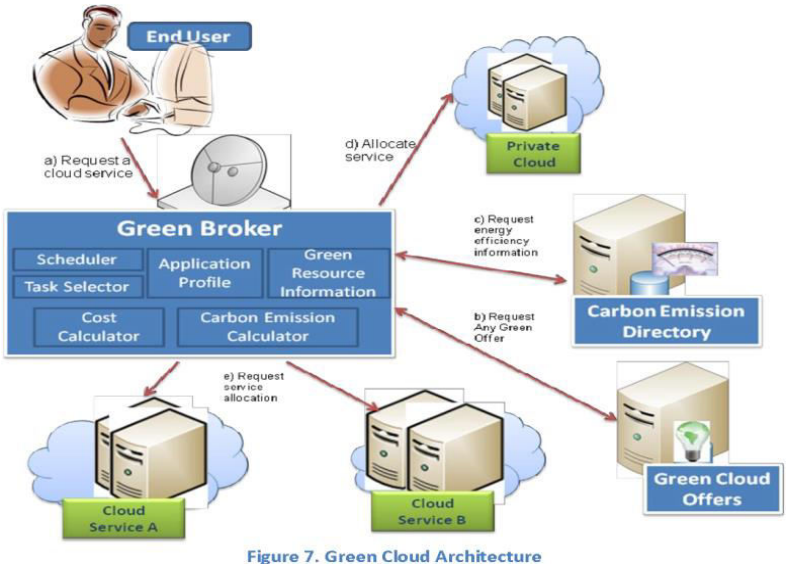

Figure 7. Green Cloud Architecture

Fig.4) Green Cloud Architecture

Tools for Estimation of Electrical Carbon Footprint

Following web-based tools can arrive at an estimated carbon footprint for data center:

1. Data Center Power Sizing Calculator: The Data Center Power Sizing Calculator defines basic characteristics of the IT load and also calculates how much utility power would be required to bear that load. The interactive nature of the tool permits the user to experiment with "what if" scenarios by modifying the load characteristics of servers, mainframes, and storage. Complete load is then calculated and the tool generates a corresponding utility power requirement.

2. Data Center Efficiency Calculator: The Data Center Efficiency Calculator profiles a data center and calculates the resulting efficiency as well as electrical cost depending on key characteristics of the data center. The user insertsthe details of the power and cooling infrastructure, and result is calculated based on a tested and validated four-parameter efficiency model.

3. IT Carbon & Energy Allocation Calculator: This tool allocates carbon emission and energy costs for data center users. Its objective is to make users aware of the energy costs they incur and also to encourage them to follow energy saving approaches like virtualization and server retirement.

4. Data Center Carbon Calculator: The Data Center Carbon Calculator tool calculates the "green" characteristic of a data center by converting energy usage rates into carbon emissions. This tool shows how hypothetical changes to a data center's location, efficiency, and IT load affect carbon dioxide emissions and the electric bill.

5. Virtualization: One of the main courses of Green Computing is virtualization of computer resources. Abstraction of computer resources, like running two or more logical computer systems on one set of physical hardware is known as virtualization. Virtualization has the ability to execute applications under many operating systems, manage IT more efficiently, and allocate resources of computing with other computers. Virtualization is a trend of Green computing. It provides virtualization software as well as management software for virtualized environments. This virtualization form of Green Computing leads to Server Consolidation and also enhance computer Security. Virtualization can also increase the efficiency of existing machine rooms, decreasing the number of physical servers required through consolidation of existing applications by introducing multiple virtual machines per server and thereby increasing resource utilization. Virtualization allows full utilization of computer resources and benefits in following:

   a) Power off Idle Virtual Server to save resources energy.

b) Reduction in total space, air and rent requirements ultimately also reduces the cost.

GREEN COMPUTING TECHNIQUES FOR ENERGY EFFICIENCY

In this section, we are presenting various techniques that can help to reduce energy consumption. We have divided this section into two categories, the first category describes such techniques that can be implemented at home, these techniques are basically for normal and average users. The second category is consisting of some advanced techniques that are specially designed for power-hungry data centers.

Ideas that can be applied and implemented at home:

- LED/LCD sleep mode: Enable the sleep mode option within the monitor, so that after some time of idling monitor will falls asleep. During sleep mode LED turns off its all emitting pixels and enters “low power consumption state”.
- Power off devices when not in use: Shutting down the system in idle period is the best effective, most natural, simplest and the easiest way to reduce energy consumption.
- System standby mode: During this mode, the computer shuts down all its components and parts except Volatile Memory, the volatile memory remains active and waits for the user command, whenever user presses some key, move a mouse or open a LED in laptop case Volatile Memory immediately active the entire system.
- Use a computer and other peripherals in power saver mode: The facility saves energy by reducing computer’s performance where possible. This method also reduces the CPU speed all the time and set the display brightness at minimum possible level.

Ideas and techniques for data centers:

- Using Clock Gating: Clock gating is an energy conserving feature in semiconductor microelectronic that is responsible for enabling and disabling the clock. Many electronic devices use clock gating

feature to disable bridges, buses, controllers and chunks of processors to reduce power consumption. It saves the electrical power used by the processor. The working criteria of clock gating are if the logic block is engaging in some work then clock of a logic block must be activated, and if there is no task performing then clock gating must be deactivated.

- Energy Efficient Processors: Modifying the clock rate of a processor or voltage of a processor is possible; we can do this with the help of "Dynamic Voltage Scaling" and "Dynamic Frequency Scaling". In dynamic voltage scaling, we can modify the voltage as per the need of current situation, whether it is related to hardware or software by increasing and decreasing it. In dynamic frequency scaling, we can set the frequency according to hardware and software need by minimizing and maximizing it.
- Renewable Energy sources: For backup purposes, usually data centers need generator powered by diesel, burning diesel come out in the form of exhaust gasses, like CO2, NOx, GHGs, and particulate matter, the diesel generator emissions these gasses into the atmosphere and pollute the nearby air quality substantially. To overcome this problem there are some other ways to produce electricity, we can use solar energy, wind energy as well as hydroelectric energy instead of diesel generator as a backup plan for data centers.
- Energy Efficient Storage: Today energy efficient storages are available in the market that can take place of current storages of the cloud. As the life expectancy of a data center has been measured up to 9 years so while overhauling existing data center renovator can use energy efficient storage like solid state Drive (SSD). As there is no moving part in SSD unlike hard disk drive, so now, SSD requires less cooling and less energy as compared to HD.

PARAMETERS USED FOR MEASURING POWER CONSUMPTION

1) Thermal Design Power (TDP)- Also, called Thermal Design Point, this term often use in CPU or GPU, the TDP is the maximum power consumption by a CPU or GPU when running a real application, at this point of time a device dissipate whatever the max power is known as TDP.

2) Power usage Effectiveness (PUE)-Power usage Effectiveness (PUE): PUE is a calculation matric, used to determine the energy efficiency of the data center, it is calculated by measuring the ratio of total energy consumption, PUE describe as the ratio of overall consumed power by the data center to the total consumed electricity by IT devices, like servers, routers, storage networking devices etc.

It is defined as: PUE = Total Data Center Power ÷ IT Devices Power

3) Data Center infrastructure Efficiency (DCiE)- DCiE is the reciprocal of PUE, these tow electricity measurement techniques are very much popular between most of the data centers.

It is defined as, DCiE = 1÷PUE

4) Performance per Watt (PpW)- It computes the energy efficiency of an individual and computer hardware or computer architecture. Usually, it is measured in Floating-point operations per second (FLOPS) and Million instructions per second (MIPS).

5) Compute Power Efficiency (CPE)- CPE is a measurement of computing efficiency of a data center. It's not fundamental all the time that we get effective work by each watt consumed by the server, some devices are power-hungry, they consume power even in idle state, yes, it is also true that 100% data center capacity will never be used but still we want as much output as possible from the electrical power.

CPE defined as, CPE = IT Service Utilization/PUE

6) Green Energy coefficient (GEC)- GEC is a measurement of how much green energy is used by the facility of the data center from green providers like hydroelectric energy, wind energy or solar energy. All these energies arrive through renewable energy sources that make data centers environmentally friendly.

GEC is defined as, GEC = Green Power/Total Facility Power

7) Energy Reuse Factor- How much energy is reused from outside of the data center, the ERF is measured that.

ERF is defined as, ERF= Energy Reused/Total Facility Power

8) Carbon Usage Effectiveness (CUE)- A measurement of CO2 emission is called Carbon Usage Effectiveness.

CUE defined as: CUE=E_{CO_2}/EIT

Where E_{CO_2}=Total CO2 emission from total energy consumed by the data center
EIT = Total energy consumed by IT Devices

9) Water Usage Effectiveness (WUE)- How much water is required for cooling by a data center yearly, it is measure that.

It is defined as: WUE= Water Used Yearly/EIT

Difference between Cloud Computing and Green Computing

CLOUD COMPUTING	GREEN COMPUTING
It is all about delivery of computing services that includes servers, storage, databases, networking, etc., over internet.	It refers to utilizing energy to perform operations in most efficient way possible.
It provides utility-oriented IT services to users all over the world.	It supports in using least amount of computing resources for doing most amount of work.
Its main objective is to provide magnitude improvement in cost effective, dynamic provisioning of IT services.	Its main objective is to attain economic viability and improve way of how computing devices are used.
It decreases energy consumption, waste, and carbon emissions, reduce carbon foot print, etc.	It decreases use of hazardous materials, increase energy efficiency during product's lifetime, manage power and energy efficiency, create sustainable business processes, etc.
It is internet service which provides computing needs to computer users.	It is that computer and technology are how much responsible for environmental change.
It permits company to diversify the network as well as server infrastructure.	It permits companies to enhance disposal along with recycling procedures.
It is less cost effective when compared to green computing.	It is more cost effective when compared to cloud computing.

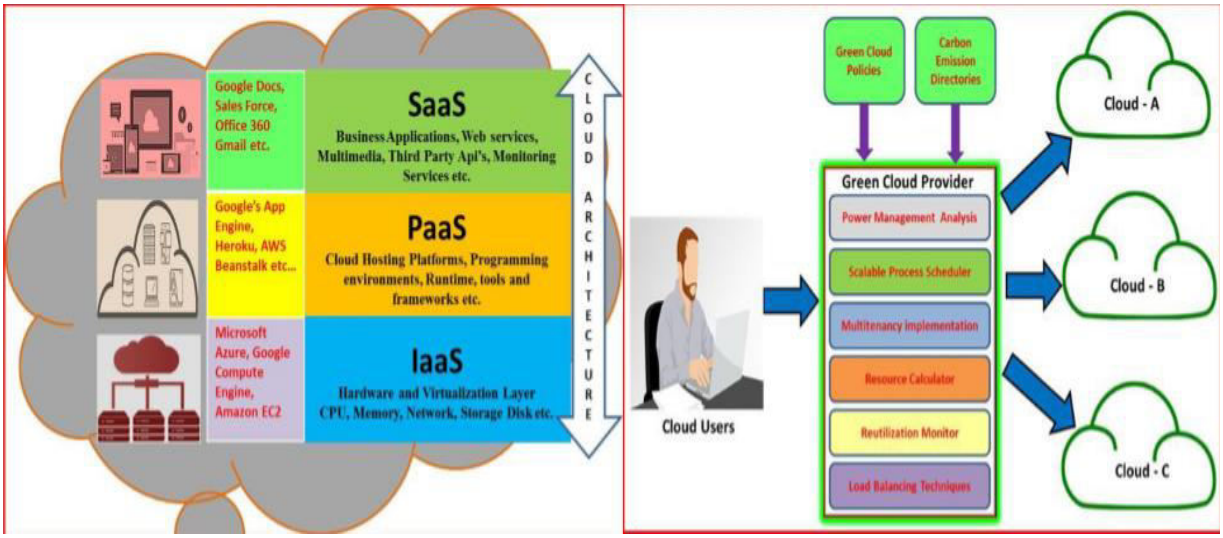

Fig.5) Cloud Computing Service Layers Architecture Fig.6) Green Cloud Computing Architecture

Challenges to Green cloud computing

1) Energy Efficiency: As the today clouds are designing with the multi-core CPU's, there is a need of designing the power optimization and management techniques to support the power management with multi-core CPU's. Another huge power consuming part of 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. By considering the today pace of IT, we need a comprehensive and intelligent mechanism to tackle with the entire cloud architecture level energy optimization issues.
2) Virtualization: Many former researches were widely concentrated on designing of the efficient cloud virtualization process, but the virtualization is still suffering from some high-end optimization relevant limitations. Designing the novel methodologies with the state-of-the-art technologies to optimize the entire lifecycle of virtualization process is an important research challenge. Automated optimal VM's creation with substantial resources and dynamic resource allocation & sharing facilities without affecting the cloud performance are the other considerable research challenges in virtualization.
3) Tenancy: Although this an essential character of green cloud, at present multi tenancy is suffering from the privacy and security concerns. Designing the secured multi-tenant architectures and privacy-preserved secured access to multi-tenant modules are the considerable future research challenges.
4) 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.
5) Eco-Friendliness: This area mainly concentrates on environment based tools design i.e. carbon emission calculator tools to measure the effect of the cloud on nature. Need to design of a

comprehensive framework to certify the clouds with ranking, based on multiple aspects of Green Cloud Computing.

FUTURE OF CLOUD COMPUTING WITH GREEN CLOUDS

The principal domain area of Green Cloud Computing is telecommuting which is the work area where in the employees do not commute to a central place of work. Teleconferencing and Telepresence technologies are the most common work areas which have been implemented using green cloud initiatives. The benefits of using these technologies with green cloud are that it increases employer satisfaction along with reducing greenhouse gas emissions which is related to travel and thus increasing the margin of profit of a corporation and thus reducing overhead costs for lights and air conditioners. Further advantages are listed below-:

1) Green Clouds helps in enhancing technological performance by improving reliability, redundancy and security by employing world class data center in a rack that operates as an autonomous server which is independent from environmental conditions because it uses DC power and have complete fire proof environment along with integrated cooling system.
2) Green Cloud's solutions will help increase the business productivity by its ease of online access and automatic upgrades with the availability of modern technology and high-quality solutions. It helps increase the employee performance as well by making the data services accessible from any location and therefore improving the overall efficiency of system along with various concerned activities required for comfortable and beneficial business.
3) One of the most main advantages of Green Clouds is the feature which is provided by Green Clouds that pay only for what is used which in turn gives the minimized maintenance of all equipment and a predictable cost structure for all expenditures required in future thus being cost efficient.
4) Last but not the least Green Clouds have very positive impacts on our environment. Energy consumption is minimized by increasing the efficiency and by using optimal server utilization. The carbon footprints as per the usage are calculated and a database of energy source composition is developed which is employed to generate electricity worldwide. Then the energy used by Green Clouds is monitored, recorded and calculated to avoid carbon emissions to build truly green environment.

CONCLUSION

In this research paper, the fact emerges that with the technological advancements, rises the need for processing abilities thus leading to an increase in the number of data centers. This results in a huge amount of greenhouse gases with in the atmosphere, impacting it in a negative way. Green Cloud computing presents a productive way of reducing the carbon impact by storing the resources virtually in a remote database.

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