MOVING CLOUD ECO-FRIENDLY WITH GREEN CLOUD COMPUTING

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Abstract— Cloud computing is one of the fast-growing and cutting-edge technologies. Simply put, it is the delivery of computing resources such as software, networking, intelligence, analytics, databases, storage, and servers to offer highly flexible resources, faster innovation, and economies of scale by using the internet as a medium. The increase in usage of cloud computing led to an increase in Datacenters (DC). The growth of data centers and the adoption of High-Performance computing (HPC) infrastructure are causing a rise in energy consumption. This led to a substantial increase in carbon emissions(CFC) in the environment and is one of the main reasons for Global Warming which should be dealt with properly. Green cloud computing is a coined term for the study of the design, manufacture, use, and disposal of computing equipment in an energy-efficient manner. It deals with finding energy-saving techniques to reduce the release of carbon emissions into the ecosystem. Eco-friendly methods are required to diminish the impact of data centers on nature. Green cloud computing is one of the prospective solutions to save the environment by using various eco-friendly methods.

Index Terms—Data centers, cloud computing, CFC, Green cloud computing, Eco-friendly, High-Performance Computing.

1. INTRODUCTION

Cloud computing is the method of using remote servers connected to the internet through a network. Cloud computing has eradicated the need to maintain physical servers individually. By using cloud services, one could connect to servers remotely and need not be worried about hardware and could store, manage and process data on which they are working. Green Cloud Computing is a process related to cloud computing that deals with the maintenance of data centers in an eco-friendly manner such that the negative impact of these data centers on the earth's atmosphere is reduced. The architecture of the Green Cloud aims in the reduction of power consumed by data centers. It helps in real-time performance to design and utilize technologies in an eco-friendly manner. It not only benefits users with cloud storage but also helps in decreasing the adverse effects of data centers on the environment. There are several ways in approaching green cloud computing, namely:

1.1 **Product longevity:**

Product longevity is one of the important steps in green computing. As the name suggests it deals with the lifetime
of the product. The goal here is to increase its life as much as possible. It is highly recommended to recycle the product rather than produce a new one.

1.2 **Data center design:**

The design of the data center has a key role in green computing. It should be constructed in such a way that the electrical, lighting, mechanical and computer systems help in maximizing energy efficiency and minimizing the carbon footprint.

1.3 **Software and deployment optimization:**

Software and deployment optimization is another important factor in increasing energy efficiency. Algorithmic efficiency, resource allocation, virtualizing, and usage of terminal servers are a few methods of software and deployment optimization.

1.4 **Power Management:**

Efficient usage of power is one of the key factors. towards green computing. Data centers consume nearly 21% of electricity consumed by the IT sector. Efficient power supply to data centers and systematic usage of storage and processing equipment could be used in the good management of power.

1.5 **Materials Recycling:**

Many harmful substances such as mercury, hexavalent chromium, and lead could be kept out of landfills by recycling the computing equipment and could also avoid
the need for remanufacturing.

1.6 **Telecommuting**:

The concept of telecommuting defines the ability of the employees to complete work-related assignments outside the traditional workplace with the help of telecommunication tools. It has greater advantages for green computing by avoiding the need to travel and thus decreasing the emission of greenhouse gases.

1.7 **Supercomputers**:

As the name suggests these computers comparatively have high efficiency and perform very well than other computers.

There are a few other techniques for achieving green cloud computing such as virtualization of servers, DVFS, virtual machine consolidation, live migration, and resource switching.

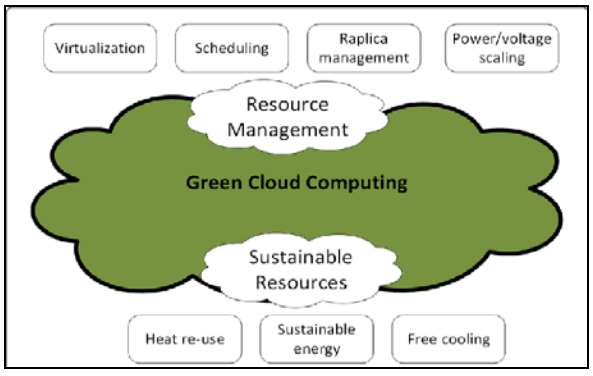

Fig 1 shows different methods through which green cloud computing could be achieved.

2. RELATED WORK:

S. P. Raja et al. [1] explored the importance of green computing in different sectors such as industries, networking, IT, and corporations. The functioning of green IT businesses that cut carbon emissions, and transportation costs and are eco-friendly are being discussed. The carbon footprint analysis of an individual and in a computing center is being discussed.

The authors [2] discussed how cloud computing is destroying nature by releasing harmful gases like carbon dioxide(Co2) into the earth's atmosphere which harms the environment. The way in which energy is inefficiently used and being wasted is discussed. The manner in which computing equipment and how green computing could be used to overcome these problems.

Seema Rawat et al. [3] discussed the issues faced in cloud computing and green cloud computing and then later explained a green cloud architecture.

A research on green cloud computing and its features is provided along with its challenges by the authors of [4].

The authors of [5] gave a clear demonstration that explains how energy efficient would it be if green cloud computing is practiced. A graphical representation of data from the survey conducted in the UAE is also being shown.

The authors of [6] provided green cloud computing importance and alternatives provided by it to the Information Technology sector in terms of energy consumption and data center load.

The authors of [7] discussed several techniques that are so far implemented in reducing energy consumption and mainly focused on the virtualization of machines.

According to the authors of [8], inefficient virtual machine migration causes energy loss and further stated that idle power wastage is the main thing that is causing energy
inefficiency.

David Guyon et al. [9] discussed ways in how HPC cloud users would be helpful in reducing virtual resources size. It is also stated that even though larger resources are fast in execution they are more energy demanding but too much size reduction of resources is not beneficial for energy consumption.

Q. Zhang et al. [10] stated that the data management in the context of Bigdata, data security, automated service provisioning, storage technologies, virtual machine migration, server consolidation, software frameworks, energy management, traffic management and analysis, and novel cloud architectures are some of the research challenges of the industry.

[11]A two-phase green algorithm is proposed to optimize approximately 20% intake of power in the cloud by conducting a migration for VMs that are less utilized to adequately utilized and also by keeping these unutilized VMs at a power-saving sleep state.

Along with virtualization, various other power-saving techniques that support green computing were discussed by the authors of [12]. An algorithm and a few other techniques for power awareness in the distributed system were also discussed. A mathematical equation for calculating the consumption of energy in computing devices was also proposed.

An Energy-efficient green cloud architecture is proposed that assists cloud providers regarding the efficient usage of computing resources by the authors of [13].

3. PERFORMANCE ANALYSIS- POWER MEASUREMENT OF GREEN METRICS:

1 Power Usage Effectiveness:

The ratio of total energy consumed by a data center to the energy consumed by computing devices is known as Power Usage Effectiveness. It expresses how productively energy is used by the computing equipment.

PUE = “Energy used by total facility/ Energy used by IT equipment”

PUE	Level of Efficiency	DCiE
3.0	Very Inefficient	33%
2.5	Inefficient	40%
2.0	Average	50%
1.5	Efficient	67%
1.2	Very Efficient	83%

Fig. 2. shows the relation between values of PUE, efficiency level, and DCIE.

2. Carbon Usage Effectiveness:

It is the ratio of Co2 emissions released by the data center into the atmosphere to the total energy consumed by the IT equipment of the data center.

CUE = “CO2 Emissions Caused by Total Data Center / Energy consumed by IT equipment”

Units: no of kgs of Co2/kWh whereas its perfect score is 0.0

3. Water Usage Effectiveness:

It is the ratio of the quantity of water used by the data center to the energy used by the IT equipment.

WUE = “Annual usage of water by data Center / Energy consumed by IT equipment”

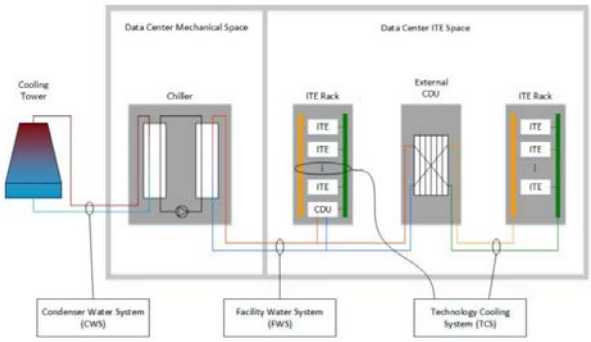

Fig. 3. shows the cooling system in the mechanical and IT space of a data center.

4. Energy Reuse Factor:

It is the ratio of renewable energy such as wind energy, solar energy, etc. to the energy used by the IT Equipment.

ERF = “use of renewable energy / Energy consumed by IT equipment”

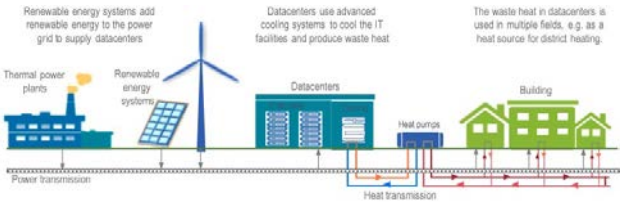

Fig. 4. shows how the heat energy is reused in a data center.

5. Energy Reuse Effectiveness:

It is the framework to find out the profit by using reused energy. It is the ratio of the difference between Total Energy and Reused energy to total IT equipment energy

ERE = "(Total energy – Reused energy) / (Energy consumed by IT equipment)"

6. Datacenter Infrastructure Efficiency:

It is used to calculate the data center's energy efficiency. The ratio of energy used by the IT equipment to the energy used by the Total facility is known as Datacenter Infrastructure Efficiency.

DCIE = "power used by IT equipment/power consumed by Total facility"

7. Datacenter Productivity:

It is used in measuring the total work that is done by the data center. It is the ratio of useful work done to the total facility power.

DCP = "Useful work / Total facility power"

8. Compute Power Efficiency:

It is used in finding the amount of energy that is solely used for computing.

CPE = "IT Equipment utilization energy / PUE"

9. Green Energy Coefficient:

It is used in measuring the quantity of green energy that provides services to the data center.

GEC = "Amount of consumed Green Energy/ Total consumed Energy"

10. Space, Wattage, and Performance: It is used in measuring the Energy and space required by the data center. It is the ratio of performance to the product of space and power.

SWAP = "Performance / (space*power)"

11. Data center Energy Productivity:

It is used in measuring the work finished by the data center when compared to the total energy consumed in doing the work.

DCEP = "Total useful work done / Total Energy used to do the work"

Power measurement metrics of a data center with formulas and units.

Parameter Id	Parameter Name	Formula	Units
1	PUE	PUE ="Energy used by total facility/ Energy used by IT equipment".	Percent
2	CUE	CUE= "CO2 Emissions Caused by Total Data Center / Energy used by IT equipment"	kgCo2/kWh
3	WUE	WUE = "Annual usage of water by data Center / Energy used by IT equipment"	Liters/kWh
4	ERF	ERF = "use of renewable energy / Energy consumed by IT equipment"	Percent
5	ERE	ERE = "(Total energy – Reused energy) / Energy consumed by IT equipment"	Percent

6	DCIE	DCIE = "power consumed by IT equipment / Power consumed by the total facility"	Percent
7	DCP	DCP= "Useful work/power consumed by Total facility"	Useful work/watt
8	CPE	CPE = "IT Equipment utilization energy / PUE"	Percent
9	GEC	GEC = "Amount of consumed Green energy / Total consumed Energy"	Percent
10	SWAP	SWAP= "Performance / (space*power) "	
11	DCEP	DCEP = "Total useful work done / Total Energy used to do the work"	Useful work/kWh

4. PROBLEM IDENTIFICATION:

Green cloud computing has few issues such as:

• **High Upfront Costs**: Maintenance of the data centers in the green computing method requires high CapEx due to which many companies might refrain from it. Although it might be cost-effective in the long term implementing it requires a lot of time and research which costs a lot of money.

• **Underpowered Systems**: As a goal of saving energy, the systems that require more power to perform would be highly impacted due to green cloud computing. This affects system performance and causes less productivity leading to a loss for the company.

•**Maintenance**: Other than implementation the maintenance of green computing systems is said to be highly difficult, expensive, and time-consuming as it is new and rapidly changing technology.

Inefficient usage of data centers would require high consumption of electrical energy in the future which should be dealt with properly.[14]

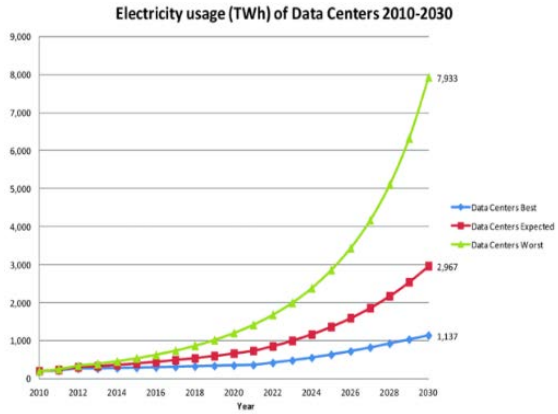

Fig. 5. shows the estimated usage of electricity based on different performance levels of data centers.

5. PROPOSED SYSTEM:

To solve the issues of green cloud computing few suggestions are advised. Application of these given points to the system would help in decreasing some of the issues of green computing such as performance, maintenance, etc.

A novel scheduling algorithm is advised to optimize allocation and consolidation of virtual machines and thus improving resource utilization of running servers and shut down of idle servers.

A clustering-based architecture could be used for reducing the energy consumption by computing resources by grouping similar requests from clients and thus increasing energy efficiency.

An approach of dynamically consolidating the Virtual machines could be used to save energy of cloud data centers. For VM live migration a novel computing approach with negligible performance overheads is advised. It would nearly save 45% of the energy consumed by a data center.

A clique star cover number technique in which more nodes could be connected to the minimum number of servers is advised to bring down the consumption of energy.

The use of Nano Data Centers is advised among conventional data centers as they have several advantages compared to conventional data centers such as less heat dissipation costs, high service proximity, self-scalable capacity, and

energy efficiency.

The usage of DVFS (Dynamic Voltage frequency scaling) is advised in minimizing the energy consumption and better utilization of resources.

A dynamic fusion task-scheduling algorithm is advised for reducing the energy consumption of a data center that can significantly decrease time and total energy consumption.

A low utilization host policy algorithm using cloudSim would be helpful for VM migration. It would not only meet energy–efficiency requirement but also helps in providing a good quality service to the customer.

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