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A SURVEY ON GREEN CLOUD COMPUTING: AN APPROACH FOR CARBON FOOTPRINT REDUCTION

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ABSTRACT
Cloud Computing Technology is very much popular and attraction of the people towards services of cloud because of low cost and high services. Hence the demand of cloud infrastructure has increased. Every data centers which are hosting the applications has consumed more energy, which create a big issue of high operational cost and high emission of carbon footprint in the environment. Therefore, the need of implementation of Green Cloud Computing to reduce the operation cost and emission of carbon footprint. Green cloud computing is an effective approach to save our environment from carbon footprint.

Researcher appreciate the need of cloud computing technology. However, everyone must be aware about the impact of carbon footprint on environment. In this paper researcher discuss the possible steps and measures to reduce carbon footprint through Green Cloud Computing, which is new technique in the field of Information Technology

Keywords: Green Cloud Computing, Carbon footprint, emission

INTRODUCTION
In this research paper, researcher analyze cloud computing technology and its use in reducing the carbon footprint.

The aim of green technology is to reduce the environmental impact of industrial processes with the growth in population resulting in new technologies. The efficient use of computers and its effect is the main concern of this paper. The bottom line considers social responsibility, economic viability and the impact on the environment. The point of research is testing and applying alternative non-hazardous materials in the products' manufacturing process.

The uses of cloud computing have made a great impact on the industries of information technology over the past few years, where big companies such as Google, Amazon and Microsoft are providing more powerful, reliable and cost-efficient cloud platforms, and business enterprises seek to reshape their business models to earn benefit from this new infrastructure and paradigm. The cloud computing is providing a powerful service.

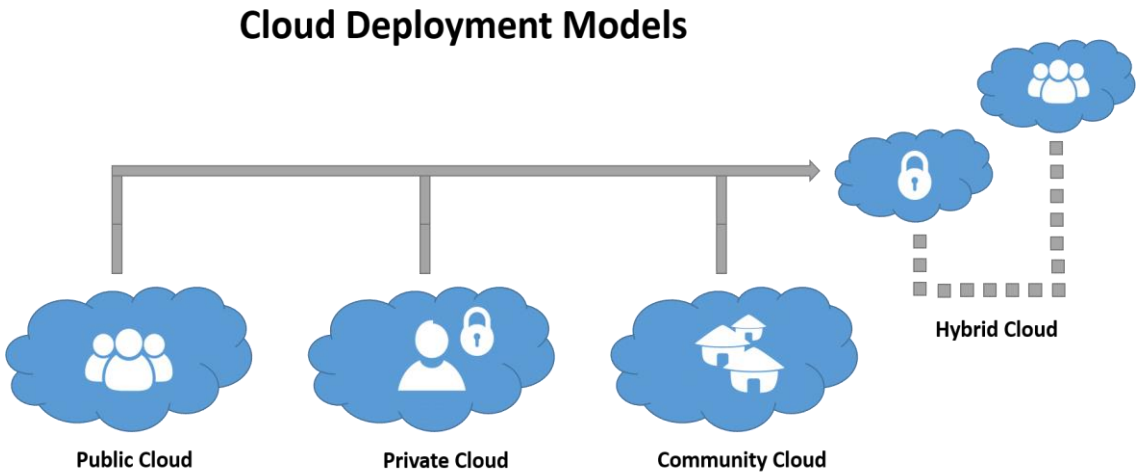
Cloud Computing is basically internet based computing where resources are u utilizing on internet.

[A] There are basically three types of cloud

i) **Private Cloud**: One client, full control over data and quality of services

ii) **Public Cloud**: A cloud which are accessed by everyone from everywhere.

iii) **Hybrid Cloud**: It includes both private and public cloud with multiple providers.



[1][Source: Google]

ISSN 2394 - 7780

[B]Cloud Architecture

The goal of cloud computing is to apply for supercomputing and high-performance computing power, normally used by Defence, Business purpose and many more trillions of computations per second. [**6]** In consumer oriented applications such as deliver personalized information, to provide data storage or to power large, financial portfolios and immersive online computer games.

The Cloud Computing framework is designed such that it keeps track of overall energy consumption of serving a user request. It has two main components, Carbon Emission Directory and Green Cloud offers, which keep track of energy efficiency of each Cloud provider and also give incentive to Cloud providers to make their service as Green Cloud Computing. From user side, the Green Broker plays a crucial role in monitoring and selecting the Cloud services based on the user requirements, and it ensure that the minimum carbon emission for every services.

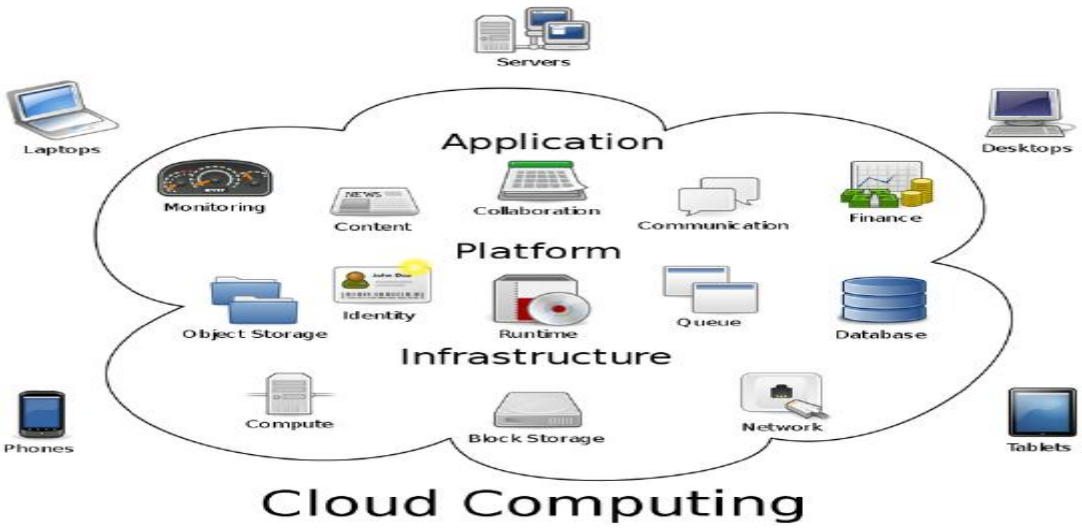
There are three types of services (SaaS, PaaS, and IaaS), and therefore process of serving them should also be energy efficient.

1] SaaS Level: Software as a Service(SaaS) providers mainly offer software installed on their own data centers. The SaaS model provides the facility to ensure the energy efficiency of their software design, implementation, and deployment.

The SaaS provider selects the data centers which are not only energy efficient but also very near to users. The minimum number of copies of user's confidential data should be maintained using energy-efficient storage.

2] PaaS level: Platform as a Service **(**PaaS) providers deals in general the platform services for application development. The platform simplifies the development of applications which ensures energy efficient system. This can be done by inclusion of various energy profiling tools such as Joule Sort It is a software energy efficiency benchmark that measures the energy required to perform an external sort. In accumulation, platforms itself can be designed to have various code level optimizations which can cooperate with underlying complier in energy efficient execution of applications. Here the Cloud platforms also allow the deployment of user applications on Hybrid Cloud except than the development of Application. Here to achieve maximum energy efficiency, the platforms profile the application and decide which portion of application or data should be processed in house and in Cloud.

3] IaaS level: Infrastructure as a Service(IaaS) Providers in this layer plays most essential role in the success of whole Green Cloud Computing Architecture, since IaaS level not only offer self-governing infrastructure services but also support other services offered by Clouds. They use modern technologies for Cloud Computing and cooling systems to save energy and make efficient infrastructure. By using virtualization, energy consumption is reduced by switching-off unused servers. There are various energy meters and sensors are installed to calculate the current energy efficiency of each IaaS providers and their sites. The information, regarding the energy efficiency is advertised regularly by Cloud providers in Carbon Emission Directory. The various green scheduling and resource provisioning policies will ensure minimum energy usage. The Cloud provider plans various green offers and pricing schemes for providing incentive to users to use their services during off-peak or maximum energy-efficiency hours. **[7]**



(Source: www.google.com)[1]

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GREEN CLOUD ARCHITECTURE

Motivation: To explore the possibilities and various methods such as using Green Cloud Computing to reduce the carbon footprint.

Objectives

i) To study theory and practices of Green Cloud Computing

ii) Reducing carbon footprint using cloud computing.

iii) Approaches of the Green Cloud Computing.

iv) To study the effectiveness of Green Cloud Computing.

Hypothesis

Carbon footprint can be reduced effectively using the cloud computing technology.

RESEARCH METHODOLOGY

i) Research Papers

ii) Magazines

iii) Websites

iv) Books

According to Webster and Watson [4], reviewing the literature is important for creating a reliable foundation for advancing knowledge. In order to obtain a sense of the current state of green cloud computing studies, we surveyed both the academic literature and non-academic studies. In the former case, we put information from conference papers, journal papers, technical reports, and some authors research and books from the Association for Computing Machinery (ACM) Digital Library, IEEE Computer Science, Scopus, and Science Direct. These databases allow access to leading computer science journals and high-quality peer-reviewed computer science conference publications [5].

LITERATURE SURVEY

Liang Hu and Jia Zhao , Gaochao Xu in their research work "A survey on green computing based on cloud environment" introduced some cloud computing technologies aimed at energy efficiency without computing the performance the objectives. They said that energy efficiency would also load to better environmental sustainability. According to them cloud computing and virtualization provide energy efficient and environment sustainable green computing. In their work they highlighted that idle power wastage is one of the measure cause of energy inefficiency with the server running at a low utilization data centers equipped with high performance infrastructure where much energy and increase co2 emission and contribute to carbon footprint.

The Green Cloud Computing is reducing energy consumption while ensuring the acceptable performance level. They concluded that some techniques on hardware systems and solutions on software framework can lead towards energy efficiency and Green Computing.

They discussed current state of energy efficiency in computer system and reviewed some existing approaches such as Dynamic voltage frequency scaling(DVFS), Dynamic Component deactivation, Advanced Configure and Power Interface (ACPI), Self-aware runtime adaptation, Heterogeneous server clustering, Power and Migration cost aware application placement in Virtualized Systems, pMapper architecture that minimizes energy consumption optimal power allocation in server forms and energy aware consolidator for cloud computing.

Chowdhury, Chatterjee etal., in their research work, "A comprehensive study on Cloud Green Computing: To reduce carbon footprints using clouds" appreciate that the future trends of ICT will be more towards cloud computing and Green Computing. They analyzed energy consumption of cloud computing by studying the clouds of different organizations and observing the energy benefits they derive.

They study different ways to decrease energy consumption of cloud computing and thereby helping to reduce the carbon footprint. In their work they pointed out techniques such as resource virtualization.

The authors concluded that cloud computing is how developing fast and efficient Hardware, Software and Server provisioning make the cloud most energy efficient platform for computing.

Singhal M, Dhurkari A, Iha M have discussed about the optimization of energy use and reduction of carbon footprint in their paper "Comparative Study on Cloud Computing in carbon cost and Energy Consumption". They disagree many energy efficient solutions.

ISSN 2394 - 7780

Laura- Diana Radu concluded a Literature survey in their paper "Green Cloud Computing: A Literature Survey". In this survey they reviewed the main achievements of Green Cloud Computing, first they provided on overview on cloud computing, then they summarized recent studies and development and finally they presented future research direction and open problems in Green Cloud Computing.

The authors have shown the studied by the different researches in the followings table

Comparison of Various cloud data centers in 2012 and 2016 [8]

Data Centers	G	PUEx	GPUE	%ENERGY
Google, Lenoir	1.63	1.21	1.97	50.5% Coal, 38.7 % Nuclear
Google , Dallas	1.490	1.2	1.79	34% Coal, 3.3% Nuclear
Apple, North Carolina	1.630	1.5	2.44	50.5% Coal, 38.7% Nuclear
Green Qloud, Iceland	1.021	1.1	1.12	70% Hydro, 30% Geo
Microsoft, Chicago	1.819	1.22	2.22	72.8% Coal, 22.3% Nuclear
Microsoft, San Antonio	1.936	132	2.32	37.1% Coal
Yahoo, Lockport	1.497	1.16	1.74	21.0% Coal, 27.0% Nuclear
Yahoo, La Vista	1.834	1.5	2.75	73.5% Coal, 14.6% Nuclear

The PUE(Power usage effectiveness) is the ratio of total amount of power used by a computer data centers.

The PUE is defined as

PUE = Total Facility power / IT Equipment power

The Green Power usage effectiveness (GPUE) mathematically defined as

GPUE = G * PUEx

G can be defined as

G= ∑ (% Energy Source *(1+Weight))

In the above table that PUEx is not a good enough metric because Microsoft datacenters have low value of PUEx and GPUE is much higher than Google or Green Qloud Iceland data centers. Due to the fact that Microsoft data centers rely more on electricity generated by coal than other non-renewable sources.

Thus, GPUE has been established as a very good metric for measuring the greenness of data centers.

DISCUSSION AND ANALYSIS

Interest in studying the influence of cloud computing on environments is on the rise due to the report published by Gartner [3], which estimated that the global ICT industry accounted for approximately 2% of global CO2.

We identified five categories of green cloud computing studies: models and methods, architectures, frameworks, algorithms, and general issues. These studies analyse and propose solutions for the following environmental issues: improving energy efficiency, efficient management of data center resources (hardware and software), reducing operational costs, and reducing carbon emissions. Some authors present their proposals and solutions for two or more environmental issues and some studies could fall into two of the categories mentioned above, e.g., frameworks and algorithms, models and/or methods and architectures or models and/or methods and algorithms.

Efficient resource management will improve cloud computing performance by reducing energy consumption, e-waste, and costs. In green cloud computing, resource management means using heterogeneous and geographically distributed resources to meet clients' requests with the minimum negative effect on the environment. Fortunately, some factors which benefit cloud computing providers also bring benefits for the environment. For example, reducing energy consumption will cut providers' costs, but will also result in reduced CO2 emissions.

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CONCLUSION AND FUTURE WORK

Cloud computing can effectively reduce carbon footprint. The primary limitation of this research is that researcher have taken data from secondary sources and limited research paper to study survey.

Future work more number of research papers of different researcher available in the field of study can be done. Primary data can be collected through survey interviews, Questionnaires, on site visit and experiment can be used to conduct empirical study.

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