

Review on Green Cloud Computing: A Step Towards Saving Global Environment

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Abstract — The Cloud Computing, most prominent internet-based computing technology wherein almost all the IT companies are planning and designing their software applications and infrastructure. It stands-out as the ever-growing and competent technology due to advancement in computing hardware, economically feasible and simplicity in use for technophile engineers over the globe. In today's green IT the energy consumption of software has increased largely, so it needs to be economic and environmental imperative. Therefore, green cloud computing is emergent in solving the issues of global warming. This paper gives you the systematic study of green cloud computing by elaborating it in various aspects like energy efficiencies, datacenter power management and virtualization with the brief discussion. We have reviewed over 14 research papers featuring various different aspects of green standards and green approaches, strategies, technologies proposed till current year in a tabular format.

Keywords — *Green Computing, Cloud Computing, global environment, Energy saving, recycling software, virtualization.*

I. INTRODUCTION

In the last few decades, the computing technology has become the essential part of the global infrastructure leading to the rise in the data usage and computing devices. Green computing provides the pathway for the use of computing resources in an environmentally friendly approach. It can be also defined as the study of designing, manufacturing/engineering, using and disposing of computing devices in a way that reduces their environmental impact [1]. The primary objective of green computing is power management and energy efficiency, but it also includes the selection of environmentally friendly hardware and software by recycling material to increase the product's life. In 1992, the launch of Energy Star Program originated the term green cloud computing for the first time [2]. Green computing improves the way computing devices are used by accomplishing economic feasibility, environmentally sustainable production practices, disposal and recycling procedures and energy-efficient resources [3]. The paper is structured as follows, first section gives detailed introduction of cloud computing, its services and deployment models, second section is a brief about green

computing followed by the third section wherein the Green IT barriers and benefits have been discussed briefly. The fourth section is a year-wise review of various cloud and green computing areas and its analysis is described in the fifth section. The brief conclusion of this paper is stated in the last section.

II. CLOUD COMPUTING IN DETAIL

A. What is Cloud Computing ?

The term cloud computing can be defined as the delivery of configurable tools for computation such as networks, storage, servers, services and applications by enabling ubiquitous convenient on-demand network access that can be released quickly with minimal management effort or interaction of the service provider [4].

B. Benefits of cloud computing for Business

Cloud computing provides benefits for business like save your money at hosting, instantly scalable resources and pay as you go pricing, strategic competitive advantage, high availability, lightning fast performance with flexible working hours and faster running apps with increased security. [5]

C. Different Types of Cloud Computing Models [6]

The growing popularity of cloud computing with tens of thousands of servers and storage devices has given rise to different types of cloud service deployment models based upon their location and can be categorized as follows:

1) Private Cloud

It is a cloud-based computing service used by stand-alone organizations that are offered either over the internet or a private internal network. These types of clouds provide high-security and are good for the organizations with high management demands, and availability requirements.

2) Public Cloud

The cloud services that are offered by the third-party providers over the public internet. It is popular among businesses and organizations of all sizes with fluctuating requirements for their web applications, webmail, and storage of non-sensitive data.

Cloud Service models [6]		
IAAS	SAAS	PAAS
The user is provided access to computing and hardware resources such as servers, storage and networking.	The user is provided with the vendor's cloud based software accessible with the help of web or an API.	The user is provided with the cloud environment with featured development, management and delivery applications with a suite of prebuilt tools.
Infrastructure is scalable in terms of processing and storage needs and it saves the costs of user's maintenance and hardware.	The use of resources is scaled depending on service needs and the vendor manages, installs or upgrade software.	It provides an environment with support for developing, testing and hosting applications support.
This model is location independent with physical security.	This model is globally accessible with easier administration and patch management.	This model comes with the support of database management system, tools for designing and developing applications with integrated server-side scripting environment.

3) Community Cloud

It is a cloud computing deployment service model between organizations that belong to a limited number of individuals or organizations such as banks, government organizations, or commercial enterprises and is managed and hosted internally or by a third-party vendor.

4) Hybrid Cloud

This model is the integration of both private and public clouds to achieve the best possible infrastructure. The

Table 1.1: Cloud Computing Service Model [6]

combination accommodates the flexibility and computing power of the public cloud for basic and non-computing tasks. A perfect example of this scenario would be that of an organization who uses the private cloud to secure their data and interacts with its customers using public cloud.

D. CLOUD COMPUTING SERVICE MODEL.[6]

Table 1.1 illustrates cloud computing service models in brief with their features and characteristics.

III. WHY GREEN COMPUTING ?

"Seventeen percent of the total carbon footprint caused by technology is due to data centers. The electricity that is needed to run these data centers is nearly 30 billion watts. These servers waste 90 percent of the energy they use because they run on full capacity all day long." [7] as stated by Pranav Prakash, the presales consultant at Photon. Green computing helps in the enhancement of the primary goals such as energy competent peripherals, improvement in the consumption of resources and electronic waste which can be satisfied due to the efficient use of computers and other technologies that enhances the overall performance of the system. In modern world, there is a need of green cloud computing models to remotely control data centers and servers to make them more energy efficient and economically reliable. While offering the cloud services, the service providers should ensure that they can provide energy efficient services with economical cost. But the challenging and complex task is to lower the usage of energy of data centers. As data is growing exponentially, the green cloud computing having issues related to infrastructures for

computations that can not only minimize the consumption of energy but can also make the Cloud services reliable and economically efficient. [8]

IV. GREEN IT BARRIERS AND BENEFITS

Table1.2: shows main barriers and benefits of green computing which was observed and studied by author San Murugesan.

Barriers	Benefits
Cost for establishment.	Minimum use of power and resource.
Challenges in re-engineering processes and revised procedures.	Better utilization of resources.
Opposing to the changes and cultural behavior.	Optimized environmental impact.
Enterprise green initiatives are not aligned properly.	Optimized operational cost.
Lack of management drive and support.	Improved cooperate image.
Opposing the need of learning new skills.	Compliance and regulatory requirements are fulfilled.

Table 1.2: Green IT: Barriers and Benefits [9]

V. REVIEW ON GREEN COMPUTING AREAS FOR CLOUD COMPUTING

Many researchers/authors had taken lot of efforts to find out better solution using green cloud computing to save global environment. **Table 1.3** illustrates total 14 papers of current decade (year 2011 to 2019), which includes what are objectives/focused points of author and what they had concluded.

VI. ANALYSIS ON REVIEW ON GREEN COMPUTING AREAS

From literature review and the table 1.3 we inferred that there is great impact of cloud computing in global

environment. But, at the same time green computing works as an antidote for cloud computing. Many authors concluded

that there should be precise rules, regulations and policies from government to increase green revolution in future.

S.N.	Year /Citation No of paper	Main focus /Objectives of Authors	Authors Conclusion
1	2019 [10]	Author mainly focuses on green computing awareness. This paper identifies the rationale, obstacles and their outlook regarding information technology.	After the study, some recommendations have been given, which could boost the adoption of green computing in budding age group and reduce the adverse effect on the environment.
2	2018 [11]	Author mainly focuses on the life cycle strategies of green computing and its practical and research implications.	The presented life cycle strategies contain individual metrics to categorize data center practice into measurable units. This study provides an effective and clear approach of presenting the general green computing practice application concept.
3	2017 [12]	Authors describes the current and future trends in green computing and challenges faced.	Authors conclude the way in which the organizations and researchers have put in a great deal of efforts in achieving environmentally friendly technologies with the various challenges overcome by them.
4	2016 [13]	In this paper authors determine and scrutinize a listing of critical success factors (CSFs) for vendors within the development of eco-friendly software. Authors has given systematic literature review from a sample of 74 research papers.	The precise writing review found by writers propose that 'merchants in the advancement of green and economical software with green structured software and effective coding', utilized of 'intensity sparing programming procedures', 'least carbon emission all through software development process', proficient asset usage, 'paperless correspondence', 'filtration of prerequisites through green evaluator' and 'e-squander the executives'.
5	2016 [14]	Authors had described their various ideas on metrics and methods for green cloud, conceptual understanding on algorithms and model designs provided by the scientist and researchers.	Authors concludes that harmful gases emitted by the working of the various components of the cloud services can be reduced by placing the virtual machines on the physical machines so that the consumption of resources can be handled.
6	2016 [2]	Authors have given details about energy star program whose major causes are – electricity consumption and generation of toxic waste. Discussed efforts of green computing towards how to use the computers.	Authors created awareness with statement that "how each one of us takes small efforts towards adopting green computing to reduce the unwanted and harmful effects of computers on the environment by reducing air, water and soil pollution."
7	2016 [16]	In this paper authors systematically reviewed and analyzed different green quantifiable metrics in environmentally friendly software, by reviewing 14 studies with different aspects of green measurements and sustainable software.	Authors analyzed that the metrics energy and performance are in current trends with minimum focus on different features of software sustainability such as pollution and recycling of software.
8	2015[17]	Authors elaborates the Green Cloud Framework, wherein the GCF adopts an all-encompassing approach to the energy efficient management, rather than focusing on a single solution.	Author concluded that recent energy-conscious software is still vulnerable and much more research is required in the development of optimized algorithms for the transparent resource allocation. It is also necessary to design both software and hardware from the start, to achieve high energy efficiency, with the rapid dynamics demanded by CDCs as a primary requirement for their designs.
9	2015 [18]	Here authors have discussed solutions on green computing and also stated some important facts regarding green computing like Power Management Techniques, Virtualization, Energy efficient coding, how to optimize repair, re-use, recycling and disposal techniques.	Authors believe that the CO2 emissions are rising day by day with the increase in the computer usage.
10	2015 [19]	Here authors have focused on how the environment is affected due to the ICT sector, discuss power savings strategies in green cloud computing systems and how these strategies help in conserving the energy consumption of ICT Sector.	Authors concludes that numerous energy-efficient methods should be incorporated in data centers to design it in the environmentally friendly approach.

S.N.	Year /Citation No of paper	Main focus /Objectives of Authors	Authors Concluded
11	2014 [21]	Here author mainly focus on green strategies for compilers, green strategies for software development, hardware energy saving methods, energy efficient data center design.	Author conclude that identifying the problems in energy use is the first step for finding ways to save energy. Also have addressed the various strategies in the design of an energy efficient data center.
12	2013[22]	Here authors presented a literature review of cloud computing in construction management which states the reduction of CO2 emissions can be achieved by using cloud computing technology in appropriate way.	Here authors identified major advantages with cloud computing for the construction management. The author has examined valuable collaborative tools and technologies as an important and valuable ICT subclass comprising cloud technology.
13	2012 [23]	Here authors discussed about current areas in which green computing is efficiently used. Challenges which were faced earlier and challenges which could be faced in future.	Authors concluded that "Technology is not a passive observer, but it is an active <i>Contributor</i> in achieving the goals of Green Computing." The research is required in the academic sector.
14	2011 [24]	Here author focus mainly on green use, green disposal, green design, green manufacturing, and also mentioned various strategies used in green computing with some tangible and intangible benefits of green IT.	Authors conclude that government should provide the proper guidelines for scrap collecting agencies as scraps created by massive use of computing resources has increased tremendously threatening the environment.

Table 1.4: Review on Green Computing Areas

CONCLUSION

Green cloud computing is the emerging technology and topic for research in this technocratic world of technical enthusiast. Now a days, IT companies are advancing towards the cloud computing due to increase in the large data storage and computational demands leading to the growth of the cloud infrastructure with ecological and frugal balance. Cloud computing has designed and developed a top-notch approach to virtualize servers and data centers with maximum energy efficiency. This paper reviews the brief discussion on green cloud computing, it's barriers and benefits to the globe. It is followed by, an annual review on green IT areas for cloud wherein the opinions and conclusions of some authors have been stated. The paper concludes that energy efficiency and power management are taken as important objectives with precise norms by the government heading towards the green revolution in near future.

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