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Original Article

A Sustainable Approach to Green Cloud Computing

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Abstract

The IT sector is now at a critical juncture, and without the development of a sustainable solution, it might have dire consequences for the globe. Most of the energy consumption in the sector is attributed to data centres. It is essential for these power centres to promptly transition to environmentally friendly and sustainable energy sources. This paper explores the dynamics of Green Cloud Computing services and conducts a literature analysis to analyse the need, obstacles, and patterns of green cloud computing. The research suggests that the future of IT is closely linked to green energy, based on an examination of its features, obstacles, and trends. The research findings highlight that the implementation of green cloud computing may significantly enhance the advantages of cloud computing and reduce its impact on the environment.

Keywords: *Green Cloud Computing, Cloud Service Models, Power Usage, Data Centres, Cloud Architecture*

Introduction

Sustainability is a paramount concern in the 21st century. The reason for this is that sustainable development serves as a survival strategy, not just for people, but also for the earth. Puthal et al. [1] emphasise that the computer sector poses a significant threat to the environment. This is because the contemporary world is unable to operate without dependence on digital technology. Most major corporations are transitioning to cloud computing for their day-to-day operations, since without it, their activities would be at significant risk. By engaging in cloud computing, the excessive energy consumption poses a significant threat to the environment. Mishra et al. [2] have elaborated on this topic by claiming that cloud computing is one of the primary domains that make use of energy resources. The achievement of sustainable development is contingent upon the transition of the cloud computing industry to use environmentally friendly energy sources. Green cloud computing refers to cloud computing activities that depend on renewable energy sources. Developing a green cloud computing strategy is crucial for sustainable growth and reducing the effects of climate change, since it is a significant aspect of both local and worldwide commerce. Nevertheless, this subject is considered radical since several organisations still use cloud computing technology that relies on non-clean energy sources. Hence, to save the environment, it is imperative to initiate "Green Cloud Computing" whereby all global organisations transition from non-renewable energy sources to sustainable and eco-friendly energy. This research aims to examine the dynamics of Green Cloud Computing. It aims to enhance the energy efficiency of the whole cloud computing business, which is recognised as a significant source of global carbon emissions, by leveraging the circular economy

Related work

Considering the significance of the area, a great number of researchers and scientists have devoted their efforts to the topic and developed technologies and solutions that are pertinent to it. The purpose of this article is to try to bring such innovative ideas to light and to initiate a discussion about the emerging field of green cloud computing.

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A discussion of the linked work may be found below.

(PUE) power Use Effectiveness.

Atrey et al. [3] state that power utilisation efficiency (PUE) is a measurement of how effectively and efficiently a data centre utilises its energy. To assess the efficiency of energy, it computes the ratio of the total amount of energy used to the amount of energy that is consumed by the information technology resources on their own. Green Grid, a group of researchers working towards the goal of accelerating the transition of data centres towards green energy, is the organisation that came up with the idea. The power utilisation efficiency (PUE) indicator is among the most essential metrics for indicating the amount of energy that is utilised and wasted in data centres.

(GCA) Green Cloud Architecture

According to the research conducted by Pandya [4], GCA is a method that can be used to rethink the architecture of data centres in a manner that is consistent with environmental sustainability. During the day-to-day operations of cloud computing, GCA is aware of both the amount of energy that is used and the amount that is squandered. It is possible to deliver a solution that is sustainable over the long term for both private and public cloud-based services by eliminating the component of the cloud architecture that is not sustainable and making the services more sustainable.

Cloud Service Models

There are a variety of service models that are now available. Some of these models are Software as a Service (SaaS), Storage as a Service (SaaS), and Processing as a Service (PaaS). All these models are included in the realm of cloud computing, and it is essential that they be compatible with the environment to ensure the continued successful operation of these services [4]. The provision of these three categories of services is the fundamental purpose of cloud computing. To facilitate the growth of green cloud computing, these services need to be adapted to comply with energy efficiency and conservation standards.

Work Flow

To get an understanding of the dynamics of green cloud computing, the research will follow a methodology that has been predetermined. Studying a variety of scholarly papers, identifying several themes that are pertinent to the subject matter, and then putting the author's own interpretation into context are all necessary steps in this process. The following provides a comprehensive technique.

Methodology for Research

A qualitative methodology is used in the methodological approach to this investigation. This indicates that non-numerical data will be gathered to provide a basis for understanding the subject matter of the investigation. In addition, the collection of experiences, views, and ideas that are associated with the subject matter is the primary emphasis of a qualitative research technique.

Collecting of Data

In this research, the secondary sources of data collecting are the main sources. When this occurs, it indicates that the published literature on the subject will be investigated. This published literature will consist of academic work that has been carried out by a variety of academics and researchers from many different countries throughout the globe.

Study of the Data

A method known as theme analysis will be used to examine the data. As Neuendorf [5] explains, a thematic analysis gives the researcher the opportunity to identify a variety of themes that are particularly significant for the subject matter that is being investigated. Specifically, it highlights essential factors that are associated with green cloud computing. The significance of these topics in cloud computing will be taken into consideration about their selection. According to what has been said, the researcher intends to evaluate a variety of academic material; hence, the topics that are overlapping in these published papers will be brought to light.

Result and Discussion

Eco-friendly Cloud Computing Features

There is a need to design a model for Green Cloud Computing as the subject is yet significantly unexplored. For cloud computing to be sustainable, this model needs to highlight its main ideas and how they relate to the environment. Regarding this, the research of Patil and Patil [6] has laid the groundwork for how cloud computing should evolve in the future. Below, you will find this figure.

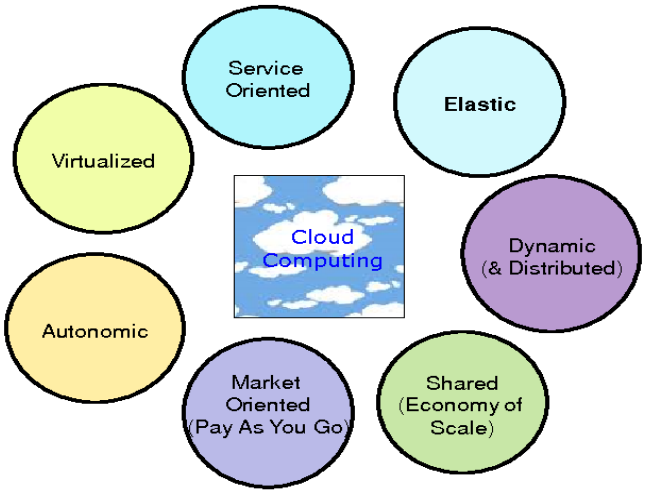

Fig 2. Characteristics of Green Cloud Computing

According to the concept, there are specific characteristics of the developing area of Green Cloud Computing. The features included in this list are energy efficiency, virtualisation, multi-tenancy, consolidation, and eco-friendliness. Two significant qualities, virtualisation and multi-tenancy, have not been addressed in this study. Virtualisation is the practice of several virtual computers using the same abstraction process. In the context of Green Cloud Computing, this implies that several computers would depend on shared task processing, resulting in a decrease in energy consumption per computer and a gain in efficiency [7].

Multi-tenancy refers to the practice of offering cloud services to numerous tenants of the same category to reduce the need for extra expenditure and energy consumption by each individual tenant [8].

While this technology has several advantages, particularly in terms of energy preservation, it also poses an immediate danger to residents' privacy. Thus, there is potential for further advancement of the multi-tenancy features of Green Cloud Computing. The last attribute shown in the workflow diagram is consolidation, as defined by Patil and Patil [6] as "the act of deploying various data centres' data processing applications on a single server using virtualisation technology." It refers to the procedures involved in Green Cloud Computing and ensuring its compatibility with the sustainable growth of the environment. These operations primarily pertain to the Application, Network, and Security components that form the foundation of cloud computing.

A Call for Eco-Friendly Cloud Computing

Pirani [9] asserts that IT accounts for around 2% of the overall world emissions. Undoubtedly, the need for cloud computing will increase in the future as analogue business models transition to digital platforms. Consequently, the emissions on a worldwide scale in the IT industry would increase, which would conflict with the well-being and preservation of the planet. This might potentially lead to the IT sector being a significant contributor to carbon dioxide emissions. Therefore, it is evident that for the IT industry to progress in the future, it must prioritise sustainability and adhere to environmental regulations. Therefore, the industry needs Green Cloud Computing to be indispensable. Data centres are significant consumers of energy in the field of IT. Therefore, any sustainable solution for IT must include a sustainable solution for data centres. The report emphasises the significance of power management and energy efficiency in today's data centres. Nevertheless, there are specific obstacles to the domain of Green Cloud Computing that will be eventually addressed.

Obstacles to the Implementation of Green Cloud Computing

The primary obstacle to the widespread adoption of Green Cloud Computing is the financial burden it entails. This topic is addressed by Burton [11]. According to the study, the data centre incurs a significant cost, and using renewable energy to operate it further increases the expenses. The report presents a cost estimate for data centres, ranging from $10 million to $12 million per megawatt. This is also a primary factor contributing to the limited number of organisations who own internal data centre capabilities. In addition, there is an expense associated with setting up a cloud computing data centre. It is worth noting that the distinction between cloud computing and conventional data centres lies in the physical infrastructure. Data centres are physically situated and maintained at specific locations, while cloud computing exists in a virtual form. Agrawal et al. [10] explore the second obstacle to Green Cloud Computing service, which is the absence of

management assistance. The IT department often lacks vigilance when it comes to adhering to climate rules, and there is also a lack of widespread understanding within the department about environmental safeguards. Consequently, the IT administration has significant challenges in persuading others about the advantages gained by powering cloud computing with environmentally friendly energy. This is now one of the most significant obstacles in the advancement of Green Cloud Computing. The lack of international regulations that promote the use of green energy is the main reason why many IT companies do not operate using environmentally friendly energy sources. Due to the technological nature of Cloud Computing, environmental organisations sometimes lack information about the energy consumption of data centres and the need for cloud computing to transition to environmentally friendly sources of electricity

Trends in Green Cloud Computing

The main point of this study is to show how important and changing Green Cloud Computing is, so it is necessary to show the most current developments and trends in the area. Radu [12] talks at length about this. The expert says that Community Cloud is the most important trend in the field. The authors Pal and Singh [13] also talk about Community Cloud. They see it as a way for organisations from different fields to work together by sharing a space to store and process activities. Why is this in the paper? Because even though community cloud uses energy that can't be replaced, the fact that it saves energy is like the idea behind Green Cloud Computing. To move forward, this kind of technology should run on green energy. This should first be done by big companies like Amazon Web Service (AWS), which is one of the biggest public cloud computer services in the world.

This research by Kaushal et al. [14] also talked about virtualisation, which is a very important change in cloud computing recently. Researchers say that the need to move away from powerful data centres is very much in line with the idea of virtualisation in cloud computing. The word "hypervisor" was used by the writers to make the process of virtualisation more well known. It's a piece of software that lets different kinds of operating systems run on the same computer. This is basically how cloud computing works, and it works great with Green Cloud Computing. Based on what the study says, virtualisation can help save up to 70% of energy, which is a huge step forward in the cloud computing business. This is also because if the computers are shared and not used for specific tasks, it can lower the amount of energy needed to cool the machines. Thus, virtualisation has the potential to make sure that the IT business will continue to grow. But, like green cloud computing, this kind of technology is still in its teens, and there are still important areas that need to be worked on before virtualisation can be used on a big scale. Security and efficiency are two of these key areas of growth.

efficiency is one of the most important problems in virtualisation. This is because efficiency is lost when systems are shared. It can also be very dangerous for security because the storage device used by multiple computers is the same. This makes it easier for people to break in and cause security problems.

Also, eco-labelling is a new trend that is growing in the Green Cloud Computing business. Companies use environmental approval to say that their products are eco-friendly, but this is more of a compliance way. It's talked about more by Di Salvo [15]. According to the experts, green labelling is more of a way for customers to choose which cloud computer companies to work with. Because of this, you can have a long-term edge, especially in a field with a lot of competition. Green labelling, on the other hand, is more of a way of thinking that companies do judge each other by how sustainable they are for the earth. Two important things that should go into green labelling are how much energy a product uses and how much carbon dioxide it releases into the air. Big and large businesses are the ones who should take the lead on this because they are the only ones with the power and means to switch to green energy. Once the biggest company in the field does this, it becomes the practice, which can then push smaller companies to do the same.

Making people aware of Green Cloud Computing is another very important thing to do. This has already been talked about a little, but it is one of the most noticeable trends of late. As Abugabah and Abubaker [16] talked about, the best way to get people to know about the benefits of Green Cloud Computing is for people to talk about it from the top down. This is something that should be done in both the business and the company. This means that leaders should be the ones who really make people in the IT community aware of the benefits and workings of Green IT. Workplace meetings should be held regularly to talk about the steps the company is taking to switch to green energy sources. The business world should read papers and magazines that stress how important it is for companies to use clean energy. Anytime everyone agrees on the need to switch to a more environmentally friendly energy source and becomes more aware of the issue, the idea of

switching the whole IT industry to clean and green energy will stay a far-off fantasy.

Conclusion

The primary objective of this research was to provide evidence that Green Cloud Computing is an essential strategy for achieving long-term sustainability. Changing from non-renewable to renewable energy sources is an important but under-discussed topic in today's IT business, as this is still a relatively new idea. This is very concerning since data centres use vast quantities of electricity, endangering the lives of countless individuals. The phrase "Green Cloud Computing," which describes the methods and procedures used to create cloud computing and other information technology resources in a way that doesn't harm the environment, is obviously necessary. The research continues by delving into key terms used in the Green Cloud Computing industry, including PUE and GCA. The industry is dealing with the issue that these criteria are not used as the foundation for assessment very frequently. Cloud computing companies may keep engaging in behaviours that threaten massive environmental degradation since their customers are clueless about the importance of energy efficiency and carbon dioxide emissions. Energy consumption measurements, virtualisation, multi-tenancy, and consolidation are some of the key characteristics of Green Cloud Computing that are highlighted in the research. These are also some of the most popular trends right now. In conclusion, we stress the need of addressing resource and financial constraints as potential roadblocks to widespread Green Cloud Computing adoption. Businesses large and small have a shared obligation to accelerate the adoption of Green Cloud Computing and other sustainable practices in the sector.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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