
GREEN CLOUD COMPUTING: AN APPROACH TOWARDS SUSTAINABILITY

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ABSTRACT

The future of the IT industry is at the crossroads, and unless there is no sustainable solution formulated within the industry, it would potentially be the end of the planet. Data centers within the industry consume most of the energy, and there is an immediate need for these power centers to switch towards green and clean energy. This study investigates the dynamics of Green Cloud Computing services and performs a literature review to examine the need, barriers, and trends of green cloud computing. By investigating the characteristics, barriers, and trends, the study proposes that the future of IT is deeply entrenched with green energy. The results of the study note that green cloud computing can be highly effective in enhancing the benefits of cloud computing further and mitigating its effects on the environment.

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

I. INTRODUCTION

The question of sustainability is at the helm of the 21st century. This is because sustainable development is a strategy for survival for not only humanity but also the planet. It is highlighted by Puthal et al. [1] that one of the biggest challenges to the environment lies in the computing field. This is due to the fact that the modern world cannot function without reliance on computing technology. Almost all of the large businesses are moving towards the use of cloud computing for daily operations, without which their activities would be put in serious jeopardy. In doing so, the energy consumed by cloud computing is putting the environment at great risk. The study of Mishra et al. [2] has further discussed this point by stating that one of the key fields which utilize energy resources is cloud computing. Sustainable development cannot be achieved unless and until the field of cloud computing is switched towards green energy. Green cloud computing denotes cloud computing operations that rely on renewable energy. Because it is among the key fields in local and international business, formulating a green cloud computing technique is at the heart of sustainable development and mitigating the impact of climate change. However, this is a very radical field as many businesses still have cloud computing technology that consumes energy that is not clean. Therefore, any attempt towards saving the environment needs to start with 'Green Cloud Computing' whereby all of the businesses around the world switch from the non-renewable source of energy towards sustainable and green energy. This paper is set out to investigate the dynamics of Green Cloud Computing. It tends to build on the circular economy and improve the energy efficiency of the entire cloud computing industry which is deemed one of the major contributors to global carbon emissions.

II. RELATED WORK

Given the importance of the field, many researchers and scientists have taken up the field and produced relevant technologies and solutions. This paper is an attempt to bring those creative solutions to light and open a debate around the new discipline of Green Cloud Computing. The related work is discussed below.

Power Usage Effectiveness (PUE)

As per Atrey et al. [3], PUE is a measure of how effectively and efficiently a data center uses its energy. It evaluates the performance of energy by calculating the ratio of energy used as a whole against the energy utilized by the IT resources alone. It was developed by the scientists working at Green Grid, which aims at a swift movement of data centers towards green energy. PUE is among the most important metric for denoting the energy used and wasted at the data centers.

Green Cloud Architecture (GCA)

The study of Pandya [4] has mentioned GCA as a way of redesigning the architecture of data centers compatible with environmental sustainability. GCA is mindful of both the energy consumed and wasted during the day-to-day process of cloud computing. It tends to provide a long-term solution to both private and public cloud-based services by removing the unsustainable part in the cloud architecture and making the services more

ecologically friendly.

Cloud Service Models

There is the existence of different service models that include Software as a Service (SaaS), Storage as a Service (SaaS) and, Processing as a Service (PaaS). All these models fall within the ambit of cloud computing, and their compatibility with the environment is critical for the future of these services [4]. The basic function of cloud computing is to provide these three types of services, and for the development of Green Cloud Computing, these services have to be made compliant with energy efficiency and conservation.

III. WORK FLOW

To understand the dynamics of Green Cloud Computing, the study will perform a pre-determined methodology. This entails studying different academic papers, carving out different themes relevant to the topic, and then bringing into perspective the author's own analysis. A detailed methodology is given below.

Research Approach

This research is approached through a qualitative framework. This means that non-numerical data will be collected in order to make sense of the research topic. A qualitative research approach is also focused on collecting experiences, opinions, and ideas related to the topic.

Data Collection

The primary source of data collection for this study is secondary. This means that the published literature on the topic will be studied. This published literature will be academic work that has been conducted all over the world by different academics and scholars.

Data Analysis

The data will be analyzed through a thematic analysis. As discussed by Neuendorf [5], a thematic analysis allows the researcher to carve out different and most important themes for the stated topic. It brings out important criteria related to Green Cloud Computing. The selection of these themes will be based on their importance in the cloud computing field. As stated, the researcher plan to review different academic material, and hence, the themes that are overlapping in these published papers will be brought into the light.

IV. RESULT AND DISCUSSION

Characteristics of Green Cloud Computing

Green Cloud Computing is a field that is still largely undeveloped, and this is the reason why there is a need for the development of a model. This model should emphasize the key themes of cloud computing and how it can be made viable with environmental sustainability. In this regard, the study of Patil and Patil [6] has produced a framework on which the future of cloud computing should be developed. This figure is given below.



Figure 1: Characteristics of Green Cloud Computing [6]

As per the above model, there are certain characteristics of the evolving field of Green Cloud Computing. These characteristics include energy efficiency, virtualization, multi-tenancy, consolidation, and eco-friendly. Among the most important of these characteristics, which are also not discussed in this paper yet, are virtualization and multi-tenancy. Virtualization is a concept whereby several virtual computers use the same abstraction process. Within the framework of Green Cloud Computing, this would mean that multiple computers would rely on the shared tasks procession, which would then ultimately reduce the energy consumption per computer and increase efficiency [7].

Similarly, multi-tenancy is a phenomenon that is akin to providing cloud servicing to multiple tenants of the same category in order to avoid additional or marginal investment and energy utilized by a distinct tenant [8]. Although this technique can have many benefits especially linked to energy conservation, there is an immediate threat of risk of privacy between the tenants. Therefore, there is room for further development of multi-tenancy characteristics of Green Cloud Computing. The last characteristic indicated in the workflow diagram is consolidation, which is highlighted by Patil and Patil [6] as "the process of deploying different data centers related data processing applications on a single server with virtualization technology. Broadly speaking, it means the process involved in Green Cloud Computing and making it compatible with the sustainable development of the environment. These processes mostly relate to the Application, Network, and Security on which the logic of cloud computing is built.

Need for Green Cloud Computing

It is stated by Pirani [9] that IT generates around 2% of total global emissions. It is also without doubt that the need for cloud computing would rise in the future, given the switch of analog business models into digital arenas. As a result, the global emissions in the IT sector would also rise, which would be contradictory to the health and safety of the planet. This might also cause the IT industry to become one of the key polluters of carbon dioxide emissions. Hence, it is quite apparent that if the IT sector is to develop in the future, it needs to be more sustainable and be made compliant with the environment. The need for Green Cloud Computing is thus essential for the industry. Data centers are among the most consumed energy centers in the IT solution, and hence, no solution of IT sustainability can be developed without forming a sustainable solution for these data centers [10]. The study also highlights the importance of power management and energy efficiency in the current data centers. However, there are certain barriers to the field of Green Cloud Computing which are discussed subsequently.

Barriers towards Green Cloud Computing

The number one barrier towards large-scale implementation of Green Cloud Computing is cost. This is discussed by Burton [11]. As per the researcher, the cost of the data center is itself very high, and making it run on renewable energy makes it even higher. The study provides an estimate of data centers which is estimated at \$10 million and \$12 million per megawatts. This is also one of the core reasons why only a few companies have in-house data center facilities. Furthermore, there is a cost for establishing a cloud computing data center as well. Here it is important to mention that the difference between cloud computing and traditional data center is of the physical space. While data centers are physically located and kept at a particular location, cloud computing exists virtually. The second barrier towards Green Cloud Computing service is discussed by Agrawal et al. [10], and it is lack of management support. IT department is usually not very cautious about the climate protocols, and there is not either high awareness prevalent in the said department regarding environmental precautions. As a result, it is very difficult for the IT management to convince about the benefits realized through fueling cloud computing with green energy. This is already one of the biggest challenges towards the development of Green Cloud Computing. It can be substantiated from the fact that many IT houses do not run on green energy, and this is primarily because there are no specific international protocols that encourage IT operations to go all green. Since Cloud Computing is a highly technical field, there is also a lack of awareness among the environmental agencies about the energy utilized by data centers and the need for cloud computing to switch to a green mode of energy.

Trends in Green Cloud Computing

Since the theme of this research is to highlight the importance and dynamics of Green Cloud Computing, it is imperative to show the recent trends and happenings in the field. This is discussed in length by Radu [12]. As

per the researcher, the most notable trend in the industry is Community Cloud. Community Cloud is also discussed by Pal and Singh [13], who regards community cloud as a collaborative effort whereby organizations from different fields share a space for the storage and processing of operations. The reason why this is included in this paper is although community cloud may run on a non-renewable source of energy, the fact that community cloud conserves and save energy is akin to the spirit of Green Cloud Computing. Having such a technology run on green energy should then be the next step which must first be implemented by large organizations such as Amazon Web Service (AWS), which is among the largest public cloud computing service in the world.

The study of Kaushal et al. [14] has also pointed to a very important development in recent times with respect to cloud computing that is virtualization. As per the researchers, virtualization is a theme in cloud computing that is very consistent with the need of moving away from high-powered data centers. In order to make the process of virtualization commonly spread, the authors have used the term Hypervisor. It is one of the software programs that allow different types of operating software to run on a single machine. This is essentially the logic behind cloud computing and is very compatible with Green Cloud Computing. As per the estimates in the study, virtualization can enable the conservation of energy up to 70%, which is truly a breakthrough in the cloud computing industry. This is also because if the servers are shared and not used distinctively, then it can reduce the cooling energy required to lower the temperature of the machines. Therefore, virtualization can and have the potential for ensuring the sustainability of the IT industry. However, as with green cloud computing, this type of technology is still in its adolescence, and there are still key areas that need to be developed for the large-scale implementation of virtualization. These key areas of development include security and performance. Performance is among the core issues in virtualization, and this is primarily because when systems are shared, there is a compromise in the performance. Similarly, it can also put the security at great risk since the storing device used for different systems is the same; the break-ins and security breaches are more widespread.

Furthermore, another emerging trend in the Green Cloud Computing industry is eco-labeling. This is more of a compliance method whereby companies use environmental certification to label them as eco-friendly. It is further discussed by Di Salvo [15]. As per the researchers, green labeling is rather a sort of evaluation criteria for the clients when assessing the selection of cloud computing companies. This can be used as a sustainable advantage, especially in an industry where there is high-intensity competition. However, green labeling is more of a mentality where the companies do judge one another through the criteria of how much sustainability they provide to the environment. Green labeling should be based on two important factors that include energy efficiency and carbon dioxide emissions. This is a responsibility that first relies on big and large companies since it is only the large companies that have the capacity and resources to make a switch towards green energy. Once this is adopted by the industry leader, then it becomes a norm that can then encourage the smaller companies to pursue the same objective.

Another very important aspect of Green Cloud Computing is awareness. Although this has been touched on in the earlier discussion, it is one of the noticeable trends in recent times. As discussed by Abugabah and Abubaker [16], the major driver of awareness regarding the benefit of Green Cloud Computing is a discourse that should flow from top to bottom. This should not only be practiced within the industry but also within a company. This is to say that the major responsibility of making aware the members of the IT community must flow from the executives that should work for invoking the consciousness among the people regarding the benefits and dynamics of Green IT. There must be regular conferences at the workplace regarding the efforts put in by the company to switch towards a green source of energy. The industry should make use of articles and journals that stresses the need for clean energy for fueling the operations of a company. Until and unless there is a consensual agreement regarding the need to adopt a more sustainable form of energy and a sense of awareness among the members of the fraternity, the possibility of switching the entire IT industry towards clean and green energy would remain a distant dream.

V. CONCLUSION

The point of departure of this study was to highlight the need for Green Cloud Computing as a way forward for sustainable development. This is quite a novice theme in the IT industry, and it must be admitted that the modern discourse in the sector does not highlight the need to make the transition from non-renewable sources

of energy towards more sustainable forms. This is quite alarming because data centers use a tremendous amount of energy which puts the lives of millions at risk. There is a clear need for Green Cloud Computing, a terminology that emphasizes the processes and practices to make computing and other IT resources in accordance with climate safety. The study then dwells on important jargon prevalent in the Green Cloud Computing sector, such as PUE or GCA. Most often than not, these criteria do not serve as the basis of evaluation, and this is one of the problems that the industry is facing. The clientele of cloud computing is in ignorance when it comes to energy efficiency or carbon dioxide emissions which serve as an incentive for the producers to continue with the practices that promise to bring large-scale destruction to the planet. Therefore, the study then proceeds to highlight the core characteristic of Green Cloud Computing which include energy usage metrics, virtualization, multi-tenancy, and consolidation. These are also among the prevalent trends in the industry. Lastly, barriers towards large-scale adoption of Green Cloud Computing such as cost and resources are highlighted. It is clear that the entire responsibility of adoption of Green Cloud Computing rests on the industry, and it is indeed the big and small companies that should make a swift transition towards sustainable development.

VI. FUTURE STUDIES

This study takes a holistic approach and outlines the current state of Green Cloud Computing. In doing so, it leaves out the specific details that can and should be researched further. For instance, Electronic Recycling Programs, Edge Computing, or Mobile Clouds are specific areas that call for a greater investigation. Hence, future studies on the topic can take a narrower approach and highlight the specific actions the industry needs to embark on in making the IT industry more sustainable. Future studies can also be based on producing criteria such as Eco-labeling or Green labeling to invoke a discourse on how the companies should select the cloud computing services. In this sense, the present study is a drop in the ocean, which is targeted to bring the entire discussion about Green IT into the helm of the world and the need for IT companies and professionals to ensure that the sector remains compliant with the protocols of climate change.

VII. REFERENCES

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