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A Study about Green Computing in Major Cloud Providers

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Abstract: The term "green cloud" refers to the potential environmental benefits that information technology (IT) services delivered via the Internet can provide society. The concept is made up of the terms green — which means "environmentally friendly" — and cloud, which is the common symbol for the Internet and the abbreviated name for a form of service delivery model known as cloud computing. When the use of cloud computing grew, so did energy consumption. This rise in energy demand has resulted in a significant increase in carbon emissions in the atmosphere. The exponential growth of data servers and other resources is causing an increase in energy demand. Cloud computing eliminated the need for physical servers in organizations and provided the ability to work remotely. In this paper we discuss about, green computing important to the major cloud providers (Amazon, Microsoft, and Google). Modern data centres that follow the Cloud computing model host a wide range of applications from those that run for a few seconds to those that run for longer periods of on shared hardware platforms. As the data centre market expands, it has an impact not only on the economy but also on the environment.

Keywords- Green Computing, Amazon, Microsoft, Google, Cloud Provider

1. INTRODUCTION

Green Cloud Computing, the term green in conjunction with cloud computing denotes that it is environmentally friendly. The idea is to reduce energy consumption as well as waste disposed of to the environment. Before delving deeper into the concept of green cloud computing, let us first define cloud computing and how it is used in organisations today. To some extent, cloud computing technology reduced power consumption. Prior to cloud computing, servers were housed in server rooms and required a constant supply of power to function. The cooling systems, like the servers, required power to ensure they did not overheat. Servers and coolers must be disposed of as their lives come to an end. With cloud computing, the amount of hardware on-premises is reduced, as is the amount of power consumed. The goal of green computing and cloud computing is to reduce power consumption even further. Campuses used the IT industry to connect servers in server rooms. Cloud computing is investigating energy-efficient methods of operation in order to reduce energy consumption. Green computing in cloud computing is the discovery and production of energy-saving digital methods to reduce carbon emissions to the environment.

The main objective of the Green Computing is minimizing energy consumption, purchasing green energy, decreasing paper work, increasing equipment disposal properly [1]. Green computing is the movement towards a more environmentally sustainable computing. It seeks to conserve the energy and reduce the e-waste. It is important for all classes of computing systems, from handheld mobile devices to data center facilities, which are heavy consumers of energy [2, 3].

Google funded a project in 2013 to measure the energy consumption and carbon emissions of cloud computing. With this new project, the amount of constant power consumed for common software programmes such as spreadsheets, email, and CRM systems is expected to be reduced by 87 percent. Organizations can go completely paperless thanks to cloud computing and green technology.

Green mobile computing storage options such as OneDrive, SharePoint, Google Drive, and Dropbox are widely used today. Documents no longer need to be printed thanks to secure cloud computing green technology such as Adobe Sign and DocuSign. With just a few clicks, these green computing tools enable users to sign, store, and send contracts and legal documents in a matter of seconds. Cloud computing is the latest trend in the field of green computing. It does away with the hardware servers and uses virtual servers. Thus, cloud computing is energy-efficient technology for ICT. It provides better resource utilization, which is good for the sustainability movement for green technology [4].

Green computing in the cloud can help manage technology resources while increasing productivity and lowering costs. The green cloud storage architecture is working to reduce power consumption while still providing customers with efficient services. The architecture incorporates power management in cloud computing via a green algorithm. The U.S. Department of Energy specifies five primary areas on which to focus energy efficient data center design best practices: information technology (IT) systems, environmental conditions, air management, cooling systems, and electrical systems. It will require green cloud computing solutions to save energy and reduce operational costs and carbon emission [5]. Every decade, there is an increase in electronic waste. The disposal of waste into the environment harms both the ecosystem and human health. The United States alone disposes of 24 million computers each year. One-fourth of all computers are donated or recycled. The e-waste then travels through a trade chain in developing countries before being imported.

Data can be safely stored in the cloud. The ability to access documents at any time and from any location is a

benefit of storing files in the cloud. Another important feature is that data is not lost, which can happen from hard drives in server rooms at times. Green I.T 2.0 is the greening by I.T and includes coordinating, reengineering and optimization of the supply chain, manufacturing process and workflow of the organization to reduce the impact on environment [6].

According to research, if a larger organisation moves even one of their major applications (such as their HR system) to the Cloud, they could save an average of 30,000 metric tonnes of CO2 over the course of five years, which is the equivalent of taking nearly 6,000 cars off the road. That has a significant environmental impact, when we think about it. Microsoft has reduced its carbon footprint by 9.5 metric tonnes, recycled nearly 10 million kilograms of consumer eWaste, and invested in over 500 megawatts of new wind and solar energy.

Indeed, Microsoft recently announced that they are testing an underwater datacenter using submarine technology, with the goal of utilising renewable marine energy and eliminating the need to cool the equipment. Google has been carbon-neutral for the last ten years, diverting 86 percent of their waste from their global data centre away from landfills, reusing 22 percent of the components used for machine upgrades, and achieving 100 percent renewable energy for all of their global operations. IBM has unveiled a new energy-efficient data centre that will reduce the carbon footprint of cloud computing clients who use it. The data centre in Research Triangle Park, North Carolina, can continuously read temperatures and relative humidity while operating, as well as adjust cooling in response to changes in demand. This process will reduce annual energy costs by 15%.

Perceptions and technology have shifted in an increasingly energy- and resource-constrained world. With the increasing demand for computation and data storage, cloud computing has become the norm. Several industries and businesses are now focusing on how to make cloud computing truly "green." Recognizing the current and future benefits of addressing energy and waste issues, as well as companies' contributions to reducing the planet's greenhouse gas emissions, has given rise to new imperatives. Cloud computing will play an important role in an IT organization's drive to become more environmentally friendly in the not-too-distant future.

1.1 GREEN COMPUTING APPROACHES

The following green computing approaches are being implemented in businesses.

Virtualization & Use of Terminal Servers:

Virtualization is the process of running multiple operating systems on the same computer at the same time. The applications that are running appear to have their own machine. The use of shared servers and terminals has been shown to save up to 80% of energy. [7]

Power Supply & Power Management:

Electricity transmission used only 60% of the available power and wasted 40% of it. Energy will be used more efficiently with green computing technology. The use of a green algorithm for power management in cloud computing reduces computer power consumption. [7]

1.2 APPLICATIONS IN GREEN CLOUD COMPUTING

Green computing is widely used in the following organizational areas:

- Energy management in data centre's
- Wireless Network in the Green
- Green Parallel Computing in conjunction with a Big Data Network
- Algorithm-based green computing.

2. RENEWABLE ENERGY AND GREEN COMPUTING ARE IMPORTANT TO THE BIG THREE CLOUD PROVIDERS

When compared to on-premise infrastructure, the public cloud provides greater scalability and flexibility to businesses. One advantage occasionally touted by major cloud providers is that moving to the cloud will make organizations more socially responsible by lowering their carbon footprint. For Example, Northern Virginia is the east coast's data centre capital, with "Data Center Alley" (not far from ParkMyCloud's office) housing more than 100 data centres and 10 million square feet of data centre space.[8] Because of the positive economic impact, Northern Virginia welcomed the data centre market. However, as demand for cloud services grows, so does the need for more data centres. Last year, the cloud boom in Northern Virginia alone surpassed 4.5 gigatonnes of commissioned energy, roughly equivalent to the power output of nine large (500-megawatt) coal power plants.

Greenpeace and other environmental organizations have accused major cloud providers such as Amazon Web Services (AWS) of not doing enough to protect the environment when operating data centres.

According to them, the issue is that cloud providers rely on commissioned energy from energy companies that are solely focused on dirty energy (coal and natural gas) and very little on renewable energy initiatives. Although the allegations have focused attention on energy firms, we wanted to know what (if anything) the major cloud providers are doing to reduce their reliance on these forms of energy and provide data centre's with cleaner energy to make green computing a reality.

2.1. GOOGLE'S PRIORITIZATION OF EFFICIENT DATA CENTERS

Google has the smallest market share of the Big Three, but it has done the most to decarbonize its results. In 2017, the company announced that all of its activities, including its data centres, were powered entirely by renewable energy. All data processed by Google Cloud is said to have "zero net carbon emissions," according to the company. Google says that making data centre's operate as effectively as possible is a major priority for them, and that reducing energy consumption has been a top priority for them for the past ten years. The method of constructing facilities from the ground up rather than purchasing existing infrastructures was Google's breakthrough in the data centre industry.

Google claims that using machine learning technology to track and improve power-usage-effectiveness (PUE) and find new ways to save energy in their data centres enabled them to introduce new cooling technologies and operational strategies that reduced energy consumption in their buildings by 30%. They have deployed custom-designed, high-performance servers that use as little energy as possible by removing unnecessary components, allowing them to reduce their footprint while increasing load power.

By 2017, Google had revealed that they were using 100 percent renewable energy from wind and solar farms, which they purchased via power purchase agreements (PPAs) and then resold to wholesale markets near their data centres. Google's most efficient data center runs at 35 °C (95 °F) using only fresh air cooling, requiring no electrically powered air conditioning.[9] Although serving the exponential growth of the internet, Google focused on reducing our energy use. Non-computing or "overhead" energy (such as cooling and power conversion) consumes almost as much energy as computing energy in most data centres. Just 11% of the overhead was eliminated by Google. As a result, the majority of the energy we use is used to fuel the computers that directly serve Google searches and goods.

In their productivity measure, Google considers all sources of overhead. If they used the loosest understanding of the Green Grid's PUE calculation principles, they could report much lower numbers. In reality, if they used a standard industry understanding, their best site might have a PUE of less than 1.06.The average PUE for all Google Data Centers is 1.11, although we could boast a PUE as low as 1.06 when using narrower boundaries, shown in Figure 1.

The cloud can support many items at once, allowing it to more effectively spread resources among a large number of users. That means we, and companies, can do more with less resources. According to research published by Lawrence Berkeley National Laboratory in 2013, shifting all office staff in the United States to the cloud could reduce the amount of energy consumed by information technology by up to 87 percent.

In terms of Google items, a case study conducted by the US General Services Administration (GSA) revealed that moving to Google Apps reduced office computing costs, electricity usage, and carbon emissions by 65-90 percent. Furthermore, a report found that companies that use Gmail had reduced their email service's environmental effect by up to 98 percent as opposed to those that use local servers. Google Cloud is safer for the climate as a result of Google's energy saving efforts. This ensures that companies that use Google's cloud-based products are often more environmentally friendly. [10]

Google launched an oil and gas division in 2018 with the express purpose of attracting the fossil fuel industry. The company claimed that its machine-learning software, when combined with its cloud service, could help those companies better operate on their data, allowing them to extract oil and gas from existing reserves more quickly and efficiently. The data centre team collaborated with Google's AI subsidiary, DeepMind, in 2019 to develop a machine-learning model that can forecast wind farm performance up to 36 hours ahead of time. This knowledge will help utilities better prepare for wind fluctuations and, as a result, increase the amount of wind energy available on the grid.

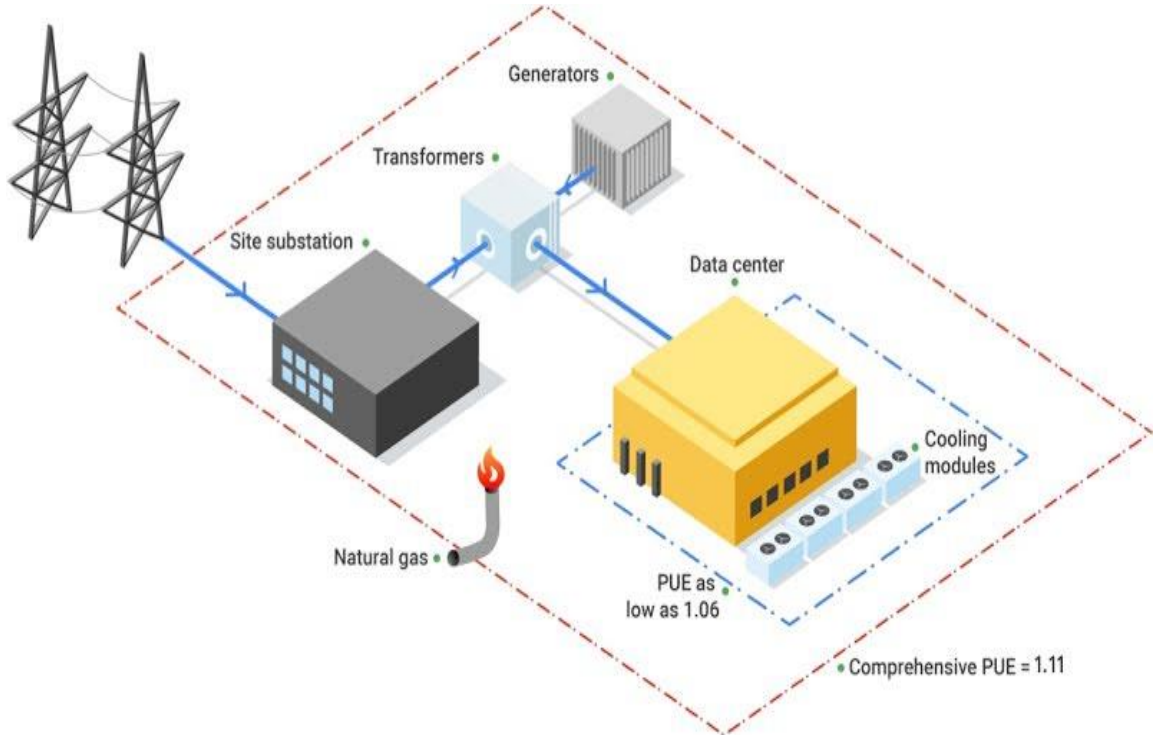

Figure 1: Google Data Center PUE measurement boundaries.

2.2. MICROSOFT DATA CENTER ENVIRONMENTAL INITIATIVES

Microsoft has confirmed that it is dedicated to change and making a positive impact on the environment through "leveraging technology to address some of the world's most pressing environmental issues." They revealed in 2016 that they would use more green energy to power their data centre's, with a goal of using 50% renewable energy by the end of 2018. However, they say that they were able to meet that target by 2017, which was a year earlier than expected. They would be well ahead of AWS if they could achieve these goals. Aside from renewable energy, Microsoft plans to use IoT, AI, and blockchain technology to track, control, and streamline data centre asset reuse, resale, and recycling. They expect to hit 100 percent renewable energy by 2023, surpassing their next goal of 70 percent.

In addition, Microsoft introduce new water replenishment projects in their facilities thatl use runoff for non-drinking water applications. The experiment, dubbed Microsoft Project Natick, was designed to see if putting data centres under water would be more cost-effective and environmentally friendly. The project's first conclusions are beginning to trickle in, and they tend to be optimistic. The center's recovery marked the end of a years-long endeavor, which was itself Phase 2 of a larger project that began in 2015 off the west coast of America, when the company sunk a data centre to the seabed for 105 days to see how computing could be done in such an intense climate.

Microsoft has introduced some unique company initiatives, such as internal carbon taxes that encourage teams, such as the Azure team, to reduce their carbon footprint. In addition, the organization is investing heavily in renewable energy ventures. It signed a five-year hydro power purchase agreement in Washington earlier this year and began talks to buy power from a new wind farm in the state. Microsoft also signed a contract for a 74-megawatt solar plant in North Carolina at the same time. According to Brian Janous, general manager of energy and sustainability at Microsoft, this takes the company's overall renewable energy portfolio to about 1.9 gigawatts. This represents a 60 percent improvement over the previous year. [11]

Microsoft has also put money into research to improve the energy quality of its current and future data centres. The company started testing data centres on the ocean floor last year, with the aim of lowering or eliminating cooling and other energy costs. Microsoft is also looking at using fuel cells to power its data centres. Microsoft, like Google, uses machine learning to make its data centre infrastructure more effective. It also operates a grant programme that provides researchers working on climate-related problems with cloud computing credits. Microsoft is looking at using natural gas as a source of energy for its data centres. Although natural gas will help with energy efficiency, it is not a renewable resource and adds to the company's carbon footprint.

Microsoft is also heavily investing in data centre battery technology growth. Turning data centres into massive energy storage sites, whether using batteries or fuel cells, will allow better use of renewable energy by capturing it as it flows easily on sunny or windy days and tapping into these stores when it's scarce. Microsoft began a pilot project using on-site batteries at a data centre in Virginia in 2018.

2.3. AMAZON: AWS'S DATA CENTER SUSTAINABILITY PROJECTS

With just over a third of the market, Amazon Web Services is by far the largest cloud computing provider. In 2014, Amazon CEO Jeff Bezos revealed a long-term commitment to using 100% renewable energy to fuel all of the company's data centres. Since then, it has built several wind and solar farms. According to AWS's sustainability team, the company is investing in green energy and green computing projects, with a target of using 100 percent renewable energy by 2040. [11]

Working with state and local environmental organizations and through power purchase agreements (PPAs) with power companies, they are proposing and supporting smart environmental policies and leveraging knowledge in technology that drives renewable innovation. When making such decisions, AWS's Environmental Layer, which is committed to site selection, design, operations, and the reduction of environmental risks for data centres, also considers sustainability. "When businesses migrate from on-premises technology to the AWS Cloud, they usually reduce carbon emissions by 88 percent," they say. This is because, as opposed to on-premise infrastructure, businesses use 77 percent less servers, 84 percent less fuel, and gain access to a 28 percent cleaner mix of energy – solar and wind power.

In 2018, AWS reported that they had made significant progress against their sustainability goals, with renewable energy use exceeding 50 percent. In the United States, AWS currently operates nine renewable energy farms, including six solar farms in Virginia and three wind farms in North Carolina. Three more green energy projects are planned by AWS, one in the United States, one in Ireland, and one in Sweden. They plan to generate around 2.7 gigawatts of renewable energy each year once the project is completed.

In a study published in 2019, Greenpeace accused Amazon of breaking its pledge to 100% renewable energy. According to the survey, only 12 percent of the energy used in some of the company's largest data centres is renewable. According to the Greenpeace study, Amazon increased its operations in Virginia, which supports the centre of its cloud infrastructure, by 59 percent in the last two years without introducing any new renewable energy. In response to the study, Amazon stated that it remains committed to using 100 percent renewable energy.

Amazon has also made it a point to keep knowledge about its carbon emissions hidden from the general public. Despite the fact that it published its global carbon footprint for the first time this year, it petitioned the Australian government to exclude it from an annual report on the country's carbon emissions. Amazon has also been

chastised for failing to have a straightforward roadmap for achieving its target of 100 percent renewable energy.

Finally, Amazon Web Services (AWS) promotes its oil and gas services. It markets its cloud service as a way to "accelerate and optimize discovery, drilling, and production," according to its website.

3. SUMMARY

Breakthroughs in cloud sustainability are occurring on a large and small scale, providing the cloud with improved infrastructures, high-performance servers, and reduced carbon emissions through increased access to renewable energy resources such as wind and solar power. Despite the promises made by cloud providers to use renewable energy, cloud services continue to expand beyond those commitments, and the amount of energy required to run data centres is still heavily reliant on "dirty energy." While some may argue that the clock is ticking, data centres – and eventually the ecosystem – will benefit if cloud providers continue to strengthen current commitments to keep up with demand. With cloud computing now playing such a large role in ICT operations, it's becoming increasingly necessary for cloud providers to understand the environmental effect of their services. They should not only ensure that they remain on top of their game, but they should also ensure that they are not harming the environment in the process.

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