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Surveying on Energy Efficient Cloud Computing Paradigms

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***Abstract*—** Cloud computing may be a price economical infrastructure enterprise. Its requirement has exaggerated the power consumption of information centers significantly. This is considered to be a critical area of concern. Therefore, there is a requirement for various solutions to save lots of energy, scale back operational prices and carbon emission that isn't friendly for the atmosphere. Hence, it is mandatory to manage the energy consumption. Essentially the main task is to implicate the answer to achieve the long-term analysis on energy efficient cloud computing. This paper offers the different methods to attain this goal. This paper conjointly discusses the advantages of Green Cloud and deals with the assorted aspects to cut back the energy consumption by cloud computing and hence reduce the greenhouse gas level in the environment. This paper includes different metrics for the measurement of energy consumption and give insight into the energy efficiency techniques by classifying into various categories.

***Keywords*—cloud computing, green products, data centers, carbon dioxide, servers, energy consumption, computer architecture**

I. INTRODUCTION

The use of cloud computing is changing into widespread. The need of information centers have been increased with the increase in data requirement by the user.The internet traffic all over the world has tripled since 2015, and there is a probability that it will get doubled by 2022 to 4.2 zettabytes per year (4.2 trillion gigabytes) [6].

Due to the exponential growth in the digitalization of the data, the demand of the electricity has been increased. In 2018, global demand for electricity in the data center was measured at 198 TWh, or approximately 1% of total final demand for electricity[10]. High energy consumption emits a large amount of carbon dioxide, which has a hazardous impact on the environment. On the other hand, it will increase service providers and user's operating costs also. In this regard, major research operations have been launched in the last few years on the data center's energy

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consumption. With this awareness, there's a growing demand for clean product and services. The environment friendly cloud, abbreviated green cloud, may be a term that is being used nowadays to reduce the environmental footprint of cloud computing The green cloud so appeared with initiatives to cut back the energy consumption of knowledge centers and their emissions of CO_2.

The inexperienced Cloud is presently a promoting tool, each for corporation's victimization it however additionally for information centers desirous to stand out from the competition.

II. RELATED WORK

This paper [4] implemented a clean energy-efficient scheduling algorithm for cloud computing data centers using DVFS technology. The DVFS property allows processors to run at mutiple frequency variations of voltages to lower the processor's power consumption. In multi-application virtualized data centers, Song et al.[22] studied the issue of effective resource allocation. The aim was to increase resource utilization resulting in lower power consumption. This Paper [12] explored the issue of energy-efficient resource management in an unified framework serving a single SLAs (Service Level Agreements) web application defined in terms of time constraints for response. Two power management mechanisms were used in the approach: switching on and off servers (Vary-On Vary-Off, VOVO) and DVFS. Anton Beloglazov[7] studied mitigating energy consumption. Researched energy-efficient consolidation of dynamic VM under QoS constraints applied to virtualized data centers with highly diverse physical resources. Rajkumar Buyya et al.[4] clarified the power and cost problems of cloud computing when fulfilling the SLAs ' QoS criteria. Paper raised the issue of allowing energy-efficient allocation of resources, resulting in Green Cloud computing. Describes the technical features of the green cloud and focuses specifically on energy-efficient data center maintenance

III. METRICS FOR ENERGY CONSUMPTION

(i) Power Usage Effectiveness: PUE could be a widely used metric for measuring power consumption. It's the quantitative relation between the full energy consumption of the infrastructure and also the consumption of laptop instrumentality (processors, memories, storage).

PUE= Total Facility Power / IT Equipment Power

PUE is measured by dividing the amount of electricity input into a datacenter by the capacity in which the computing system is operating. Therefore, PUE is measured as a ratio improving overall performance as the quotient declines to 1.

(ii) Data Center Infrastructure Efficiency: DCIE is the reverse of PUE. It is represented in terms of percentage and it gets better as its reaches to 100 %.

DCIE= IT Equipment Power / Total Facility Power

(iii)Carbon Usage Effectiveness : Cue is defined as a quantitative approach for calculating the emission of CO_2 per kilowatt-time . Data center administrators can measure the CO_2 emission by reading their electrical meters and multiplying that value by their local carbon factor. Larger data center administrators will measure the CUE by dividing the total CO_2eq of the power consumption of the facility by the total IT energy usage.

CUE= Total CO_2 emission from DC energy/ Total IT Equipment Energy

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$CUE= (kgCO_2/KWh) * PUE$

(iv)Water Usage Effectiveness : With the help of this metric, the manager can measure the usage of water within the datacenter

WUE= Annual Site Water Usage/ IT Equipment Energy

IV. OTHER MATHEMATICAL INDICATORS

- **Thermal Design Power**

The TDP is the maximum amount of heat that an infrastructure's component can generate. Its higher value indicates the higher heat emission by the system.

- **Performance per watt**

Quantifies the maximum computing capacity of a processor per watt used. This marker must be high as possible.

- **Compute Power Efficiency**

In addition to the performance per watt, the CPE takes into account the non-computing time consumption and the percentage of use of these components:

CPE= percentage utilization/PUE

V. TECHNIQUES TO MINIMIZE THE ENVIRONMENTAL FOOTPRINT

It has been shown that *cloud computing* generates vast carbon footprint in environmental. However, there are many techniques for reducing it, these techniques concern the software , Hardware and Infrastructure aspect as well. The same is elaborated in the Figure.

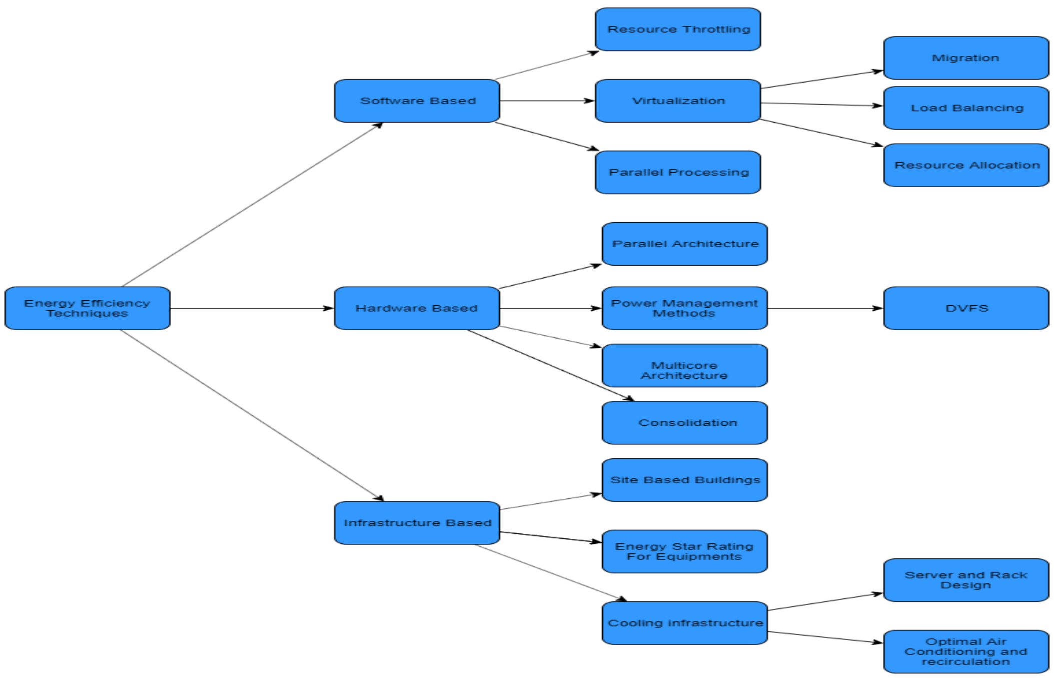

Figure 1: Taxonomy of Energy Efficiency techniques to reduce carbon footprint.

Different techniques are available to reduce the CO2 emission produced by the data centers and it is applicable at various level.

1.**Software Based**

(i) *Resource Throttling:* It refers as a technique to reduce the need of resources in the system by the different users in a given period of time. For example, API throttling is used recently in the cloud computing.

(ii)*Virtualization:* Virtual machines are considered as an essential component in datacenter design, particularly due to their ability to isolate, consolidate, and migrate. Additionally, to the present, they allow information centers to produce users with secure, versatile and economical solutions. As in the virtualized environment, the same number of resources will be used among multiple users, It improves the resource utilization. Multiple However, some operations on these virtual machines may be valuable in energy, this can be the case of migrations. In virtualized environment multiple techniques are available such as VM migration, Load balancing of the VM's, and the resource allocation according to the utilization of the servers.

Vm Migration involves moving virtual machines from one physical machine to a different. If they're valuable in energy, then this process will leads to decrease in energy consumption and to consolidate the employment. Load Balancing also includes the transferring of the virtual machine from one host to another so that the load between multiple host will be maintained. This technique helps in achieving maximum resource utilization. To attain this goal, proper resource allocation is required. Different algorithms are available for it such as Dynamic resource allocation is one of the method in which according the requirement the resources will be distributed to the different users.

(iii)*Parallel Processing***:** Parallel processing is a technique of splitting up and executing multiple microprocessor program tasks simultaneously, thus reducing processing time. Parallel processing can be done via a two or more processor device or a computer network.

2. Hardware Based :

(i) *Parallel Architecture* : The parallel processing, explained above ,will be implemented with the help of parallel architecture to enhance the performance of the system.

(ii)*Multicore Architecture*: Multicore refers to an architecture that incorporates the fundamental logic of more than one processor in a single physical processor. For packaging or holding these processors, a single integrated circuit is used. Such integrated circuits are referred to as a die. Multicore architecture places and bundles multiple processor cores as a single physical processor. The goal is to create a system

(iii)*Power Management Technique* : There are various techniques available for reducing the power consumption used by the different resources. **Dynamic voltage and frequency scaling** (**DVFS**) is one such widely used method. It is the enhancement of power and speed parameters on the different processors, controller chips and peripheral devices of a computer system to

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optimize resource allocation for operations and enhance power savings when these resources are not required. DVFS provides systems with the minimum amount of energy needed to perform the necessary tasks. For almost all modern computer hardware, the technology is used to optimize energy savings, battery life and system durability while retaining the quality of ready-to-compute performance.

(iv) *Consolidation*: Consolidation of the virtual machine (VM) tends to be a major emerging solution for alleviating the problems related to high power consumption and emission of harmful gases in cloud data centers. The cloud system basically consists of numerous physical servers and can run multiple virtual machines on each of these servers. Theoretically, according to their resource requirements, VM consolidation combines and re-assign target VMs into as few running physical servers as possible. Underused servers should be switched or switched off to the sleep mode so that no power is consumed. Because of the fixed consumption of energy by server units, servers running at the maximum utilization level are considered as power efficient.

3. Infrastructure Based:

(i)*Site Based Buildings* : Organizations can save energy by taking advantage of free cooling by constructing data centers where renewable resources are available and build in naturally cold locations. Specifically with regard to energy efficiency, these changes are expected to significantly save 620B kWh across 2010 and 2020

(ii) *Energy Star Rating* : Multiple industry strategies are enhancing database element performance. For example, enterprise server and data center based ENERGY STAR ® initiatives and 80 PLUS ® accredited power supplies increase the efficiency of IT equipment.

(iii)*Cooling Infrastructure:*

Although building data centers in naturally cold areas makes a significant contribution to more ef fective
data center cooling, data center service operators may intensify this impact by installing external air economizers which depend on the natural surroundings rather than a cooling power source. Some factors help lower energy use and lower carbon footprint, including lightweight building, minimal-emission materials, waste reuse, and renewable heating and cooling energy sources. Alterations such as updating air compressors, powering off idle servers, use of hot/cold aisle, conversion to LED lighting can have a huge effect over time.

VI. MARKETING ASPECT

With the impacts of world global warming, corporations are progressively forced to scale back their environmental footprint to enhance their image. The cloud computing SLA is a contract between cloud providers and users which requires cloud providers to deliver their services within the context of QoS parameters such as quality of service uptime, reliability, price, service rewards and consequences for breach of agreement . SLAs are the way for a client to measure that the requested service meets a precise level of environmental quality. These SLAs enable a cloud supplier to not solely offer services supported by QoS parameters but provide green solution of it. Therefore, the extra prices are borne solely by customers willing to scale back the adverse impact of their services on the environment.

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VII. CONCLUSION

With escalating internet use and data storage and processing needs, the scale of global data centers has increased dramatically. This has caused a significant rise in data center power consumption scales. In addition, data center power consumption is exceeding the constraints imposed by cooling solutions and power delivery thermal limitations. As the diversity of data center service grows, energy management strategies are projected to become a critical part of potential organizational frameworks, which also maintain high efficiency and competitive prices. In this paper, we discussed the various metrics for measuring the power consumption. Furthermore, several possible strategies to reduce power consumption were reviewed, which ultimately eliminates the effects of carbon footprints in the environment.

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