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Green Cloud Computing- Next Step Towards Eco-friendly Work Stations

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***Abstract*— Cloud computing is a solution to various computational problems by offering different services through the internet making use of various resources. IT industry always face energy consumption and carbon emission problems. Datacenters play crucial role as a support in cloud computing. That's why the urge to open more and more datacenters is increasing day by day. As a result of the higher power usage at data centers, this boosts the economic and environmental costs. Furthermore, the increased release of CO_2 and other gases has resulted in an increase in carbon footprint and, as a result, the greenhouse effect. These are the forces that propel green computing technology forward. A brief introduction of cloud computing, related relevant researches and various approaches to use green computing is provided in this paper. Measurement, modelling and prediction of consumed energy by different organizations is necessary to maintain the environmental balance by reducing carbon emission as well as to make sure to avail the presently available energy resources for our upcoming future generations. The elaboration of several research issues in implementing green computing as well as their solutions is discussed in this paper.**

Keywords*— *Green computing, google search, power consumption, electronic equipment, cloud data centers.

I. INTRODUCTION

Green computing is currently being considered by enterprises and IT industries in order to enhance environmental aspects for a better quality of life for humans. It's a good way to safeguard the environment from the negative repercussions of toxic materials used in computer device manufacture. Green Computing [1] is a term that refers to evidence and study that involve the computing long product life from crib to death in order to conserve energy. It encompasses all elements of computing equipment, including their manufacture, use, recycling, and dumping [2]. Green technology is primarily concerned with improving production processes, conserving resources, and recycling important computing gear. Green Cloud Computing is acknowledged to be a vast topic and popular field for research due to the increasing rise of big data storage and computational requirements. Cloud computing has brought about an optimum and impressive technique to envisage servers and data centers and make them energy efficient in order to profit on various IT resources.

IT resources use a lot of power and energy, which results in a scarcity of energy and a disturbance in the global environment. As a result, green cloud computing is required to develop options that not only make IT resources more environmentally friendly but also reduce running costs.

The urge to optimize cloud throughput has arisen as a result of computational offloading and the rising requirement for rapid and adequate responses for real-time operations. Furthermore, the enormous expansion in data and searches has necessitated the construction of a huge number of data centers around the world. As a result of the higher power usage at data centers, this boosts the economic and environmental costs. Furthermore, the increased release of CO_2 and other gases has resulted in an increase in carbon footprint and, as a result, the greenhouse effect. These are the forces that propel green technology forward.

CLOUD COMPUTING: The term "cloud" refers to a collection of data centers from which different applications can be accessed via the Internet. There are three types of services in this category: SaaS (Software as a Service), IaaS (Infrastructure as a Service) and PaaS (Platform as a Service) [4] [5]. Table1 shows Wastage of power on daily basis in an IT center. Customers that purchase a SaaS service, such as Salesforce.com, gain access to a software or service that is hosted in the cloud. Consumers have access to platforms through PaaS, allowing them to deploy their apps and software on the cloud. Consumers who use IaaS get the ability to govern and manage systems in terms of storage, internetworking, applications, and software platforms, but they do not have control over the cloud infrastructure. Other solutions, such as CaaS (Communications as a Service), are a subset of SaaS that is specifically tied to a business or industry and is intended to represent hosted IP telecommunication services [7].

ABOUT GREEN COMPUTING:

Green ICT (also known as green computing or Green IT) is defined as "Green Computing is the study and exercise of efficacious and lucrative engineering, making, utilizing, and

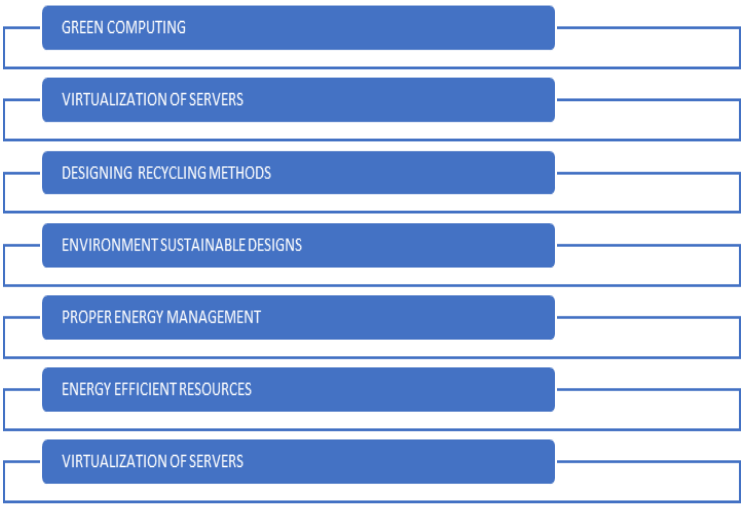

Fig1. Green computing.

discarding of computers, servers, and ancillary sub-parts as storage devices, displays, printers and networking and communications systems—without having any significant impact on environment." [3]. Fig.1. depicts points included in green computing.

CO_2 levels above a certain threshold can be harmful to one's health. The highest allowable CO_2 concentration in an 8-hour working session, according to the Occupational Safety and Health Administration, is 5,000 ppmv. Excessive and harmful CO_2 levels, which are in the range of 30,000 – 50,000 ppmv, can produce nausea and an increase in cardiovascular and pulmonary frequencies due to oxygen shortage. At 100,000 ppmv, unconsciousness and sudden death are possible [3].

II. Need of Green Computing

Computer hardware systems are getting increasingly ubiquitous and integrated into worldwide networks, resulting in large-scale deployments of computing devices to deliver a variety of services. Computers and electronic gadgets are used in practically all fields today, including information technology, medicine, education, commerce, and agriculture, causing environmental impact explicitly or implicitly. When we use a computer, a specific amount of carbon dioxide is released, which evidently has a negative impact on the users. Fig2 depicts full lifespan of an electronic equipment and Fig3. Depicts Percentage of power consumption by devices at IT centers. Computers and other modern gadgets contribute to a higher carbon footprint [7]. Fig.4. shows power consumed for a single google search. The total harm caused by all of these causes can be classified into three classifications: A. During the production process. B. During the usage of computers. C. During the decomposition process. We will try to investigate all of these issues in this section.

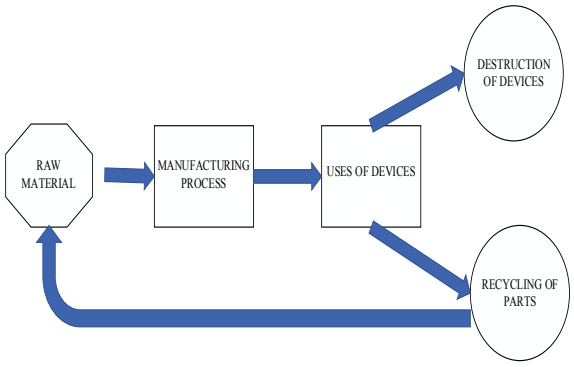

Fig2. Full lifespan of an electronic equipment.

MANUFACTURING PROCESS: Various toxic elements, such as Lead, Mercury, and Cadmium [13], are utilised in the fabrication of computing equipment, which are hazardous to both nature and humans. Lead is frequently used in the soldering of printed circuit board (pcb) and other parts, such as CRT glass. Eight pounds of lead may be found in older cathode ray tube monitors. Lead can harm endocrine system, blood system, kidneys and the central nervous system as well as have a severe impact on children's cognitive development. Lead builds up in the environment,

Table1. Table showing Wastage of power on daily basis in an IT center

DEVICES	HOURS OF USAGE FOR 1 DAY	ENERGY CONSUMPTION IN WATTS WHILE ON-STATE	ENERGY CONSUMPTION IN WATTS WHILE STANDBY MODE	ENERGY WASTED
ELECTRIC KETTLE	1	72	12	65%
PC	2	57	10	67%
CHARGER	5	9	7	50%

causing harm to biotic components. Lead generally gets collected on the outermost surface of soil that can stay there for years and can cause serious harm. Batteries, switches, and printed circuit boards, among other things, contain mercury. Healthcare industry, data transmission systems, telecommunications devices, and mobile phones all contain mercury. Mercury disperses in water and converts to dimethyl mercury, which is easily absorbed by biological organisms. Methylated mercury can result into severe brain damage and affects the food chain via fish that resides in contaminated rivers. Cadmium is utilized in semiconductors, chip resistors, and infrared detectors. Cadmium gets accumulated in the human body, especially in the kidneys. Besides of these three, there are several hazardous compounds such as PVC plastic, hexavalent chromium and brominated flame retardants, as well as silicon, carbon, and sulphur, all of which are extremely damaging to the human body and the ecosystem.

USE OF COMPUTER: When we use computers or other electrical gadgets, we utilize a significant amount of non-renewable energy. Furthermore, a significant amount of energy is squandered when a computer is idle, as the CPU, fan and other equipment as well as apps such as screen savers, use power. When we compare the electricity consumption of devices during actual use and sleep mode, we can see that the energy consumption ratio is higher during standby mode. For instance, an inkjet printer requires twelve watts of energy while printing and five watts while idle state.

DESTRUCTION PROCESS: Toxic materials such as lead, cadmium, and beryllium may be present in computer trash components such monitors and printers.

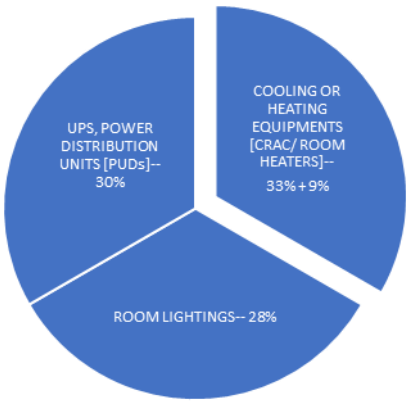

Fig3. Percentage of power consumption by devices at IT centers

Numerous sorts of gases and liquids are created from various harmful components during the disassembly and recycling of computing devices [12]. This may not have an impact on the typical computer user, but it will have a significant environmental impact. Due to various dangerous exposure in recycling processes and leaking of contaminants such as heavy metals from dumps and incineration ashes, e-waste recycling and dumping may pose a substantial danger to workers and residents. If we are contemplating about upgrading and renovating office computers, we may not pay as much concern to safe E-waste dumping.

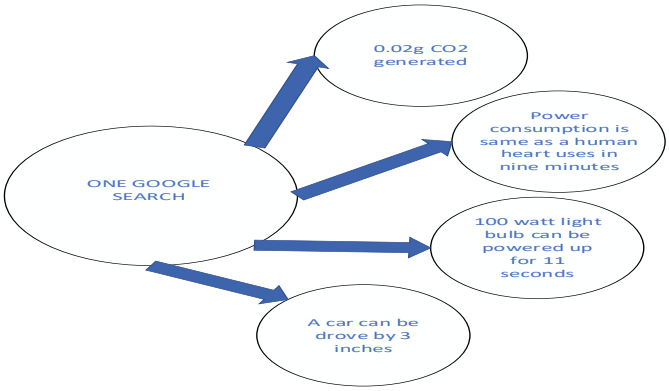

Fig4. Power consumed for a single google search

III. DIFFERENT TECHNIQUES TO ACHIEVE ENERGY EFFICIENT CLOUD COMPUTING

Marta Chinnici and Andrea Quintiliani [7] established a system for evaluating data centre energy efficiency enhancements. The principle employed is energy re-use (renewable energy). Since DCs have made significant contributions to society, their lifestyles have improved. As a result of this, demand for DCs has skyrocketed and is expected to continue to do so in the foreseeable future. As a result, a universally acknowledged assessment method is required.

The notion of dynamic migration in SLA-based energy efficiency optimization for green cloud computing was suggested by Muhammad Anan and Nidal Naseer [8]. This notion was severely restricted to SLAs, but it did so by utilizing the most significant technological method, software defined communication. This approach is solely related to server virtualization.

S. Usmin et al. [9] suggested a technique for green computing that optimizes or minimizes the number of servers active. The EVISBP method is a viable online bin packing algorithm. This method controls the virtual machine topology for load balance and energy conservation.

Arthi T and Shahul Hamaed H [10] presented an approach focused on live virtual machine migration. This allows VMs to be moved from one physical node to another on the fly. As a result, the system's operational expenses and energy usage are reduced, allowing for greater data flexibility. Data can be pre-processed before big computations, which is a feature of migration. Previous literature also looked at several green IT topics for cloud computing and came to the fact that there are many different areas that can be concentrated on. These aspects incorporate effective energy efficient supplies, server virtualization, CO_2 emission reduction, some recycling technologies, data center design, power management and so on.

R.Yamini [11] proposed the GREEN algorithm, which is an energy-conscious task aggregation heuristics method. This algorithm decreases pollution while also lowering energy use. Hassan Haghighi [12] and Negin Kord suggested a strategy for VM energy efficiency in a cloud-based data centre. It uses a fuzzy analytical hierarchy technique to deliver the VM with the lowest correlation co-efficient. This method achieves a good balance of power efficiency and SLA violation minimization. To minimize the entire power usage of a VM,

Fahimeh Farahnakian et al. [12] proposed a 3-level hierarchical VM consolidation approach with the goal of lowering energy usage and lessening the frequency of migrations in a cloud computing system. This strategy cuts down on energy usage, migrations, and SLA breaches.

Flavien Quesnel et al. [14] suggested a power model focused on dynamic power use. This framework accounts for both dynamic (CPU) and static (memory) resource use.

Table3- Table depicting previous works related to Green cloud computing

S.NO.	PURPOSE	REFERENCE NO.	ILLUSTRATION
1	To manage power consumption	[1]	Data centers relying on renewable energy
2	Efficient use of energy	[2]	Major points to improve the energy efficiency of cloud storage devices were discussed.
3	To minimalize the consumption of energy by data centers	[3]	Energy efficient web servers speed scaling by using stochastic service decision.
4	Survey of data centers to minimize CO2 emission	[4]	Overview is given on green metrics that are applicable to data centers.
5	carbon emission control and usage of virtualized servers	[5]	Clique Star Cover Number technique for virtualization to minimalize the consumption of energy.
6	To archetype a distributed and sustainable data center.	[6]	Server management.
7	Replacement of elements with more energy efficient ones.	[7]	Usage of elements having more energy efficiency. Only two technologies have been compared.
8	Dynamic migration algorithm (DMA)- To minimalize the consumption of power and CO_2 emission.	[8]	Less power consumption can coexist with efficient use of resources.
9	Practical online bin packaging algorithm (EVISBP)- Reduced the active number of servers.	[9]	Balancing of load and mitigation of hotspot.
10	Automatic VM migration	[10]	Pre-requisite data of the usage of cloud

	employing trigger engine.		services.
11	Green algorithm- To provide an eco-friendly way for energy usage.	[11]	Operational costs directly got reduced.
12	Three- tiered VM consolidation method- Reduction in the migrations and consumption of energy.	[12]	Reduction in the consumption of energy and violations of SLA.
13	The minimum correlation coefficient for VM using fuzzy analytic hierarchy process.	[13]	Reduction in SLA violations and efficient usage of power coexists.

IV. APPROACHES TO GREEN COMPUTING

a) **Improved data center cooling techniques**: It can be done by relocating servers nearer to cooling systems to focus cold air in the desired location and reducing energy losses, as well as employing water-based air conditioning units.

b) **Voice over internet protocol**: It's a catch-all word for systems that send voice messages or other forms of connectivity through the internet. Because of VoIPs, telephonic writing is becoming less common, minimizing the amount of metallic waste.

c) **Recycling and proper disposal of wastes**: It is a critical factor since it reduces the emission of hazardous poisonous gases into the atmosphere and allows for the reuse of obsolete computer parts, hence minimizing trash output.

d) **Storage**: Hard disk drives with a tiny structure element (e.g. 2.5 inch) are using less power than drives with a larger physical size. As the cost of hard drives has decreased, capacity ranches have tended to increase their potential to render more information available on the web; this incorporates archival and reinforcement data that was previously retained on tape or other offline storing media [15]. Power consumption got increased due to hike in the usage of online storage. The goal of reducing the amount of power required by huge storage clusters at the same instant maintaining the advantages of online storage is a work in progress.

e) **Terminal servers**: Terminal servers also plays vital role while aiming for green computing. Terminal clients are connected to a server at the center when using computers; the major portion of the task is performed on the server, although the end client interacts with the terminal operating system. Lesser energy consumption may be aimed by merging with small clients where one-eigth part of total amount of energy is used [16]. The use of terminal services with delicate clients to create virtual labs has increased.

f) **Virtualization and eco-friendly capacity**: Virtualization of PC refers to the encapsulation of computer assets, for an example a single set of hardware running more than two PCs. A system administrator may use virtualization to turn a couple of physical systems into virtual computers on a single, powerful system, effectively disconnecting the real hardware and lowering power and cooling use [17].

g) **Operating system support**: Since Windows 95, the popular windows required to operate system Microsoft Windows has had basic computer power management tools. This offered for standby (suspend-to-RAM) and an assess low power situation for the first time. With a new hardware driver model and substantial changes in obscured OS Windows-2000 was the 1st NT-based OS to involve power management; other features like group policy and customizable windows from central location was also facilitated. As a part of Windows NT-family of OS Microsoft also developed Windows 10. After an official announcement in September 2014 following a demo at Build 2014, the OS went into open beta testing in October 2014, preparing the stage for and continuing until the retail edition of Windows 10 on July 29, 2015, and its volume commercial launch on August 1, 2015. To bolster its case, Microsoft said that during its first year of deployment, Windows 10 would be free to customers who purchased genuine copies of eligible Windows 7 or Windows 8 editions. 1.

h) **Consolidation**: Consolidation is the practice of combining data from multiple data centers on a single server using virtual technology. It accomplishes load balancing at the process level. It conserves energy and minimizes energy consumption.

V. CONCLUSION

Many enterprises have adopted the cloud as a result of its widespread appeal and multiple benefits. As a main consumer of energy and a source of carbon emissions, the industry's growing environmental challenges necessitate power-saving strategies. Different approaches are executed in such a fantastic way that a clear reduction in usage of energy can be expected without causing any hindrance to the good performance. IT companies account for around 2% in gross CO_2 emissions in the atmosphere. Different ways for making data centers implementing cloud computing, more efficient have been looked into, the most important of which is server virtualization. It is clear from this analysis that energy efficiency and power management are considered common and significant goals. Cloud computing can reduce energy usage and carbon emissions by boosting system efficiency, according to studies of various scenarios.

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