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A Review on Green Cloud Computing

Gaganjot Kaur*, Dr. Pawan Kumar
Student (M.Tech-CSE) Punjab,India, Dean Academic & H.O.D(CSE)IITT Pojewal, S.B.S Nagar, Punjab
gaganjot28784@gmail.com, pawanjal123@gmail.com

Abstract: Cloud computing is emerging as a critical information communication technology to heavily impact our daily life in the future. As computing becomes increasingly pervasive, the energy consumption attributable to computing is climbing that marked the foundation of Green Computing. Green Cloud is an Internet Data Center architecture which aims to reduce data center power consumption, and at the same time guarantee the performance from users' perspective, leveraging live virtual machine migration technology. Saving energy or reduction of carbon footprints is one of the aspects of Green Computing. Green Cloud Architecture enables comprehensive online-monitoring, live virtual machine migration and VM placement optimization. A Green Cloud System responds to peak utilization periods and adjusts availability of resources based on them expanding or shrinking the cloud as needed.

The aim of this paper is a literature study of the challenges and various issues in field of Green Computing and discusses the future scope of Green Clouds.

Index Terms: Green Cloud computing, virtualization, security, recycling, data centers, cloud architecture.

I. INTRODUCTION

Green Clouds combines and scatter excess cloud capacity. The cloud platform of Green Clouds reacts to the speedy increasing, prerequisite for adjustable quantity on one hand, and large number of wasted in reserve on other. Green Clouds emerges as a solution to save power by utilizing server consolidation and virtualization technologies. Fine tuning resource utilization can reduce power consumption. Cloud computing platform is the next generation IT infrastructure that enables enterprises to consolidate computing resources, reduce management complexity and speed the response to business dynamics. Improving the resource utilization and reduce power consumption are key challenges to the success of operating a cloud computing environment. To address such challenges, we design the **Green Cloud architecture**.

The Green Cloud Architecture is a flexible architecture with offline configuration and server implemented clones. The Green Cloud Architecture includes the Green Broker that analyzes user requirements. It calculates cost and carbon footprint of services and carbon aware scheduling, The Green Offer Directory lists services with their discounted prices and green hours and The Carbon Emission Directory contains data on Power Usage Effectiveness, cooling efficiency, carbon footprint, network cost. It helps user to select cloud services with minimum carbon footprint. The Green Cloud Architecture enables comprehensive online monitoring, live virtual machine migration, and VM placement optimization. The Green Cloud Architecture infers a concern over the structure and the social responsibility of energy consumption so aiming to insure infrastructure sustainability without breaking contracts. Therefore, the Green Cloud architecture reduces unnecessary power consumption in a cloud computing environment. Green Cloud architecture, help consolidate workload and achieve significant energy saving for cloud computing environment, at the same time, guarantees the real-time performance for many performance-sensitive applications. The Green Cloud leverages the state-of-the-art live virtual machine migration technology to achieve the objectives of improving computing performance and reducing the energy consumption and carbon footprints.

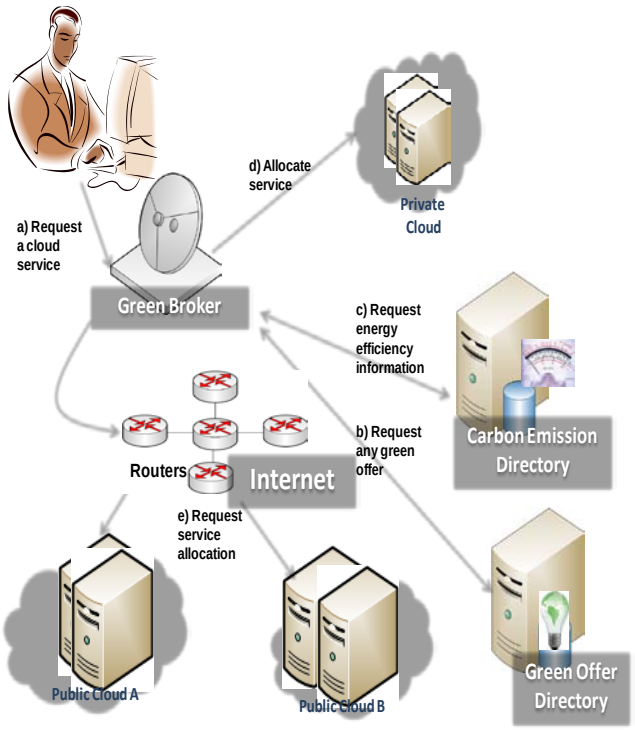

Figure. 1: Green Cloud Computing Architecture

A. *Energy Consumption:*

Organizations are realizing that the sources and amount of their energy consumption significantly contributes to greenhouse gas (GHG) emissions. In response to this awareness, organizations are currently using the following equation:

Reduced Energy Consumption = Reduced Green House Gas Emissions = Reduced Operational Costs for the data center and business [1].

The issue of energy consumption in information technology equipment has been receiving increasing attention in recent years and there is growing recognition of the need to manage energy consumption across the entire information and communications technology (ICT). The increased usage of ICT with increasing energy costs and the need to reduce greenhouse gas emissions demand for energy-efficient technologies that decrease the overall energy consumption of computation, storage and communications. The management of power consumption in data centers has led to a number of substantial improvements in energy efficiency. A typical data center consumes energy in four basic areas: (i) Critical Computational Systems that is servers, network and storage. (ii) Cooling Systems. (iii) Power conversion such as Power Distribution Units and (iv) Hoteling.

II. GREEN DATA CENTER APPROACH

Green Data Center approach will continue efforts to reduce greenhouse gas emissions and help preserve the environment. Data Center energy is related to carbon emissions and three key factors that affect carbon footprint of a data center are: **Location, IT Load and electrical efficiency**. A geographical location which experiences extreme temperatures and humidity levels will consume more energy as the data center physical infrastructure systems work harder to maintain consistent, moderate temperature and humidity levels. IT load reflects how much power the IT equipment in the data center consumes. The IT load consists of all of the IT hardware components that make up the IT business architecture: servers, routers, computers, storage devices, telecommunications equipment, as well as the security systems, fire and monitoring systems that protect them. Loads can go up (an increase in processing requirements from the lines of business) or down (impact of virtualization or consolidation).

The higher the load, the more power will be required to keep it up and running and the higher the carbon footprint. A number of factors in a data center can bring efficiency up or down. Automated tools such as the Schneider Electric Data Center Carbon Calculator, Data Center Efficiency Calculator, IT Carbon & Energy Allocation Calculator, and Data Center Power Sizing Calculator Tradeoff Tools™ can help data center professionals understand how they use electricity, and to recognize how changes in efficiency can impact carbon footprint. These tools do not consider embedded carbon – the emissions from power used to manufacture, deliver, and dispose of equipment and materials used in the data center and in the construction of the building that contains it.

A. Tools for Estimation of Electrical Carbon Footprint:

Following web based tools can arrive at an estimated carbon footprint for data center:

a. Data Center Power Sizing Calculator- The Data Center Power Sizing Calculator defines basic characteristics of the IT load and calculates how much utility power would be required to support that load. The interactive nature of the tool allows the user to experiment with "what if" scenarios by modifying the load characteristics of servers, mainframes, and storage. Total load is then calculated and the tool generates a corresponding utility power requirement.

b. Data Center Efficiency Calculator- The Data Center Efficiency Calculator profiles a data center and calculates the resulting efficiency and electrical cost based on key characteristics of the data center. The user inputs details of the power and cooling infrastructure, and results are calculated based on a tested and validated four-parameter efficiency model.

c. IT Carbon & Energy Allocation Calculator- This tool allocates carbon emission and energy costs to data center users. The goal is to make users aware of the energy costs they incur and to encourage them to pursue energy saving approaches such as virtualization and server retirement.

d. Data Center Carbon Calculator- The Data Center Carbon Calculator tool calculates the "green" characteristic of a data center by converting energy usage rates into carbon emissions. This tool shows how hypothetical changes to a data center's location, efficiency, and IT load affect carbon dioxide emissions and the electric bill. The inputs to the carbon calculator are straightforward:

(a). Physical infrastructure details for two scenarios – before and after

(b). IT load – before and after

(c). Geographical location of the data center

e. "Green Data Center in a Rack"- This approach incorporates cloud computing using low power CPUs, servers, renewable energy. For Green Cloud Computing in general 42 units high rack is designed with low energy usage equipment. Each rack contains the ability to perform complete data center functions. It can provide content management, web services, email, calendaring and other applications that are cloud enabled. This "rack" design can be powered using renewable energy integrating the solar charge controller and batteries into the rack. Using this green data center rack reductions can be made in three main areas: Power Equipment, IT Equipment and Cooling. The Green Cloud Computing Data Center in a rack requires 94% less energy that makes renewable energy both feasible and affordable.

	Switch Gear	**UPS**	**PDU**	**IT Gear**	**Zone AC**	**Total**
Green Cloud Rack	0.05	0.08	0.05	.6	0.2	**0.98 KW**

f. Virtualization- One of the main trends of Green Computing is virtualization of computer resources. Abstraction of computer resources, such as the running two or more logical computer systems on one set of physical hardware is called virtualization. Virtualization is able to execute applications under many operating systems, manage IT more efficiently, and allot resources of computing with other computers

[2].Virtualization is a trend of Green computing it offers virtualization software as well as management software for virtualized environments [3]. This virtualization form of Green Computing leads to Server Consolidation and enhance computer Security. Virtualization can also increase the efficiency of existing machine rooms, reducing the number of physical servers required through consolidation of existing applications by introducing multiple virtual machines per server and thereby increasing resource utilization. Virtualization allows full utilization of computer resources and benefits in:

(a). Reduction of total amount of hardware;
(b). Power off Idle Virtual Server to save resources and energy; and
(c). Reduction in total space, air and rent requirements ultimately reduces the cost

g. Green Power Management- There is several different issues; first of all, the merger must be carefully considered as combination of different workloads under common physical suitability of the host. Therefore, in order to determine which components of critical workloads can be packaged together, understanding the nature of the work is rather important. Second, there are problems of a performance and energy optimization because they can cause performance degradation and lead to increased execution time which eats up the energy derived from the lower idle energy savings.

In addition, there are several problems affecting the integration, including the behaviour of servers and workloads, the performance from the implementation of change and the optimal combination of different applications which accept the optimal solution not to interrupt the work load in order to keep track with the changes. All problems above become important integration of energy efficiency [4]. Our Green Power Management (GPM) saves power by dynamically right-sizing cluster capacity according to workload demands. It recommends evacuation and powering of hosts when CPU is lightly utilized. GPM recommends powering hosts should back on when either CPU utilization increases appropriately or additional host resources are needed to meet user-specified constraints. GPM executes DRA in a what-if mode to ensure its host power recommendations are consistent with the cluster constraints and objectives being managed by DRA. Hosts powered of by GPM are marked in standby mode, indicating that they are available to be powered on whenever needed. GPM can be awakened from a powered-of (ACPI S5) state via wake-on- LAN (WOL) packets. WOL packets are sent the by front-end host in the cluster, so GPM at least keeps one host powered on at all times. The performance of the system is improved with high and similar population of resources thus resulting in an increased throughput.

h. Green Cloud Security- Security is a big issue in the cloud and GREENCLOUDS is fully aware of that. The security principles of the platform are based on the concepts of Jericho and Sabsa resulting in end to end security. They are enabled and encouraged by the unique characteristics of the platform. GREENCLOUDS uses industry standard and compliant securities, but adds a unique extra layer.

All members of the cloud take part in the security platform, which acts like a value chain. Once connected, every member works in accordance with the same security protocols and consequently becomes active in maintaining those. GREENCLOUDS calls this high level security and it makes for an unparalleled and highly effective security platform that maximizes the protection of information whilst minimizing the areas of concern. Cyber Guarder, is designed to address several key security problems within the 'green' cloud computing. It provides three different kinds of services; namely, a virtual machine security service, a virtual network security service and a policy based trust management service. Specifically, the proposed virtual machine security service incorporates a number of new techniques which include (1) a VMM-based integrity measurement approach for NetApp trusted loading, (2) a multi-granularity NetApp isolation mechanism to enable OS user isolation, and (3) a dynamic approach to virtual machine and network isolation for multiple NetApp's based on energy-efficiency and security requirements.

Secondly, a virtual network security service has been developed successfully to provide an adaptive virtual security appliance deployment in a NetApp execution environment, whereby traditional security services such as IDS and firewalls can be encapsulated as VM images and deployed over a virtual security network in accordance with the practical configuration of the virtualized infrastructure. Thirdly, a security service providing policy based trust management is proposed to facilitate access control to the resources pool and a trust federation mechanism to support/optimize task privacy and cost requirements across multiple resource pools.

III. ISSUES OF CLOUD COMPUTING

As cloud computing is used widely, its applications are increasing the challenges or problems that are faced in by cloud computing are mentioned as below due to which green clouds came into existence.

a. Privacy and Security- As cloud computing is achieving its esteem the concerns about security and privacy issues also increases. Security issues include sensitive data access, privacy, data recovery and multi-tenancy issues. In the cloud computing approach both customer and the provider defines the means of processing thus increasing the chance of risk. Physical Control of any cloud equipment is more secure than having equipment off site that is why green clouds are recommended where in an added benefit is that certain set of technologies can be employed which allows a person to feel as if they are present at a place other than true location making it easier for the information to travel in both direction between user and remote location thus reducing the cost effectiveness and increasing the productivity.

b. Economic Development Issue- The main issue of cloud computing was that the economy was degraded and maximum shares were employed for use of good Information and Communication Technology (ICT)

resources and staff. Cloud computing offers more elasticity towards these ICT resources for its compatibility issue and thus making the environment and economy unsustainable. Green Cloud Computing had played an important role in increasing the economy and had a greater impact on the performance of some major government agencies as well. A study by the research firm International Data Corporation (IDC) suggested that the developing markets such as India, Brazil, China and Russia are likely to be important market forces to drive globally towards green clouds and even according to the Springboard Research China and India have the most promising effect to the green cloud related services [5].

c. ***Some other issues-*** In spite that the cloud computing have given the maximum achievements over the last few years still there are some issues around its Green accreditations like the Power Consumption using clouds is still at unacceptable high levels that is the cost of power has jumped to 50% of its hardware[6]. There are still too many manual process employed during cloud computing and the current storage technique fails to offer low cost and most important the complexity of data centers has not been reduced it's just that the cloud platforms are more likely the virtualize servers.

The above mentioned issues have given rise to the development of Green Clouds with more beneficial Green Data Center like Incubaid, Green Power Management and Green Security Systems which are environment friendly as well as economically sustainable also.

IV. FUTURE OF CLOUD COMPUTING WITH GREEN CLOUDS

The main **domain area** of Green Cloud Computing is telecommuting which is the work area where in the employees do not commute to a central place of work. Teleconferencing and Telepresence technologies are the most common work areas which are being implemented using green cloud initiatives. The advantages of using these technologies with green cloud are that it increases employer satisfaction along with reducing greenhouse gas emissions which is related to travel and thus increasing the profit margin of an organization and thus reducing overhead costs for lights and air conditioners. Energy consumption accounts for a large portion of the operating cost of computing clouds. In an EPA report to congress, it was estimated that data centers in the cloud make up 3% of the total energy consumption in the U.S. in 2011[7].

This massive energy consumption creates financial and environmental issues and along with it imposes limitations on system accuracy and scalability. As cloud computing is considered to be the future of computing and more work will be moved to the clouds, improving its energy efficiency will be more pressing and important. Green Cloud makes such a move smooth, comfortable, and beneficial for energy consumption. Green Cloud's solutions can help manage technology resources, drive productivity, and reduce costs – and make a positive impact on the environment in the process. Green Computing is the movement towards a more environmentally friendly and cost effective measurements. Following are the benefits of green clouds in different aspects that make the future of cloud computing brilliant and glittery.

A. Advantages:

a. Green Clouds helps in enhancing technological performance by improving reliability, redundancy and security by using world class data center in a rack that operates as an autonomous server which is independent from environmental conditions as it uses direct current power and have complete fire proof environment along with integrated cooling system. The Green Cloud Data Center is also known for its Green Cloud's Mirror-Imaged Disaster Recovery solution in which the data is housed in Green Cloud Virtual environment with its high performance environment powered by infrastructure composed of CISCO and VMware technologies [8].

b. Green Cloud's solutions will help increase the business productivity by its ease of online access and automatic upgrades with the availability of latest technology and high quality solutions. It helps increase the employee performance as well by making the data services accessible from any location and thus improving the overall efficiency of system along with various concerned activities required for comfortable and beneficial business.

c. One of the most important advantages of Green Clouds is the feature which is provided by Green Clouds that pay only for what is used which in turn gives the minimized maintenance of all equipment and a predictable cost structure for all expenditures required in future.

d. Last but not the least Green Clouds have a very positive impact on our environment. Energy consumption is reduced by increasing efficiency and using optimal server utilization. The carbon footprints as per the usage are calculated and a database of energy source composition is created which is used to generate electricity worldwide and then the energy used by Green Clouds is monitored, recorded and calculated to avoid carbon emissions to build truly green environment.

V. CONCLUSION AND FUTURE DIRECTIONS

Technology is an active contributor in achieving the goals of Green Computing. The main key initiatives towards manufacturing Green Computing are equipment recycling, virtualization, power management. In this paper we discussed the green clouds, its architecture and analyzed the Green Data Center approach including its security and Green Power Management. In the review of paper it also shows the future of computing with green clouds. Current trends of Green Computing are towards efficient utilization of resources. For the future research work Dynamic Resource Allocation Technique should be used to manage the workload to increase the efficiency of green clouds. As in **for future reference** the practical approach of Green Clouds are hoteling where in the square footage per

employee is reduced as workers reserve space only when it is required and in Voice over IP the telephony wiring infrastructure is reduced by sharing the existing Ethernet copper and most importantly Green Cloud Computing program and certification programs are demonstrated like Information System Examination Board(ISEB) Foundation Certificate in Green IT is appropriate for showing an overall understanding and awareness of green computing[9]. Green Clouds are most beneficial in areas where climate favors natural cooling and renewable electricity is readily available. Green Data Centres Rack are more efficient in countries like Finland, Sweden, Switzerland where in favorable conditions including the renewable source of energies reduces the high carbon footprint and thus reducing the overall energy consumption[10].

It is important to develop intelligent techniques to take care of the challenge in Green Cloud Computing that is to minimize resource usage satisfying quality of service requirements and robustness and also new approaches and proposals should be analyzed and validated. There are still number of research activities that can be planned to carry out to improve the performance of Green Clouds and bring profitable measures for users to achieve their problem solving transactions and their collaboration in Green IT where in security concerns must be surely addressed as more the cloud computing will increase there is a chance of increasing threats as well.

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Short Bio Data for the Author

Gaganjot Kaur, Student (M.Tech-CSE) Punjab, India

gaganjot28784@gmail.com

Dr. Pawan Kumar,Dean Academic & HOD (CSE),IITT Pojewal, S.B.S Nagar,Punjab

pawanjal123@gmail.com