Green Cloud Computing- Future of Green IT

Manjinder Kaur
Master of Computer Application
IGNOU, New Delhi (India)

ABSRACT:- Green cloud computing is a catchall phrase that includes efforts to improve sustainability both with in the IT industry and outside of it . The green IT movement seeks to reduce energy use ,waste, and toxic substances by IT industry.In many other industries mobile and computing devices connected to network enable sustainability through automation ,virtualization and reduced travel.Green computing is a topic of increasing importance with IT industry.Cloud computing technologies have high performance at relatively low cost. With the increasing growth of large data storage and computational demand, Green Cloud Computing is known to be a broad area and hot field for research. Green Cloud computing is environment friendly. Green cloud computing is the study of designing, producing and using digital devices in a way that reduces their impact on the environment. Not only can these solutions save energy but can also reduce operational cost. Green cloud computing involves designing, producing, and using digital spaces in a manner to reduce its impact on the environment. A green cloud solution can not only save energy but significantly reduce enterprise operational costs. Green cloud computing allows users to utilize the benefits of cloud storage while decreasing its adverse effects on the environment, ultimately affecting human well-being.

The goals of green computing are similar to green chemistry ,reduce the use of hazardous materials,maximize energy efficiency during the product lifetime and promote the recylability or biodegradability of defunct products and factory waste. These technologies have the potential to improve energy efficiency and to reduce carbon footprints and (e-)waste. These features can transform cloud computing into green cloud computing. To protect our environment from cloud negative impacts, the service providers must adopt and update their cloud infrastructure towards green computing. Green computing methodologies can help us to build a protected place for us to live in. Green computing researches widely focus on designing of efficient clouds with green characteristics like Power Management, Virtualization, High Performance Computing, Load balancing, Green data center etc. As part of my research on green clouds, this paper presents an analysis report about the green cloud computing and its characteristics in detailed manner. This paper thoroughly discusses about the former green computing achievements, current trending concepts of green computing and future research challenges as well. This comprehensive green cloud analysis report helps the naïve green research fellows to learn about green cloud topics and to understand the green cloud future research challenges.

Keywords: Green Cloud computing, Cloud computing, Virtualization,
Energy efficiency, Environmental protection, Multitenanacy, Sustainability.

Introduction:-

Green Computing is used to achieve not only efficient processing and utilization of computing infrastructure,but also minimize energy consumption.It is also called as GREEN IT. Since a decade cloud computing became the popular computation platform for business organizations and helps the entrepreneurs to concentrate on their essential business operations instead of investing their time and money on infrastructure management. According to NIST (Peter Mell and Tim Grance,2011), the cloud computing offers various services like IaaS, PaaS and SaaS, to attract the business applications owners in adopt and migrate the cloud services to their business app modules as presented in Fig. 1. Cloud based data centers, platforms, servers and the other infrastructure services are enough elastic to supply the sudden demand of huge resources from customers.Green cloud computing reduce the use of hazardous material,it causes harm to environment.It offers a detailed fine grained modeling of the energy consumed by the data center IT equipment ,such as computing servers,network switches and communication links.Green cloud can be used to develop novel solutions in monitoring ,resource,allocation,workload scheduling as well as optimization of communication protocols and network infrastructures.It is released under the General Public License Agreement and is an extension of the well known NS2 network simulator.

Today most of the gadgets like smart phones, tablets, smart watches, health care devices and the sensors are connecting to clouds for their private data storage purpose. Most of the software applications like e-mails,

messengers, enterprise apps, social web networks, e-cart apps, audio and video streaming apps, broad-casting and entertainment services are utilizing the cloud services to store, process, share and secure their data. The most popular search engine giant Google hosted all of its services like Gmail, Google Earth, Google Drive, Google Play and YouTube on their personal cloud platform (GCF) to offer the high quality services to its worldwide customers. In September 2018, Forbes published the cloud statistics (Forbes & Gartner survey, 2018) revealed that, the worldwide public clouds revenue value is 175.8 billion dollars now. With the growth rate of 17.3% the public cloud revenue is forecasted to record 206.2 billion dollars in 2019, is indicating the fastest growth rate of cloud utilization worldwide. Amazon web services (AWS),Microsoft's Azure, Google cloud platform, IBM Cloud are the popular cloud services offering vendors in today cloud market.

Fig.1 Cloud Computing Service Layers Architecture

Cloud computing, being an emerging technology also raises significant questions about its environmental sustainability. While financial benefits of Cloud computing have been analyzed widely in the literature, the energy efficiency of Cloud computing as a whole has not been analyzed. Through the use of large shared virtualized datacenters Cloud computing can offer large energy savings. However, Cloud services can also further increase the internet traffic and its growing information database which could decrease such energy savings. Clouds are addressing the majority of the problems encountered by today business organizations, but they are suffering from few notable limitations are huge power consumption, more CPU idle times, need of deploying the resources at upper bound, emission of carbon gases and producing huge electronic waste (e-waste) material. Henceforth there is a need of developing today cloud environment as eco-friendly like "Green Cloud Computing". The general cloud computing mainly concentrates on storing and processing of data efficiently, whereas the term green cloud computing is a novel reform in cloud computing which is introduced with the main goal of transforming the cloud environment as eco-friendly (Hilty M.L, & Arnfalk P, et al, 2006). The main characteristics of green clouds are energy efficiency, virtualization, multi-tenancy (high-end utilizable), consolidation, automation, resiliency, recyclability and sustainability of cloud. resources. World's green nature must not be affected by the naïve innovations like cloud computing, henceforth the experts are strongly recommending that the "cloud computing must consider the ecology gaining along with economy".

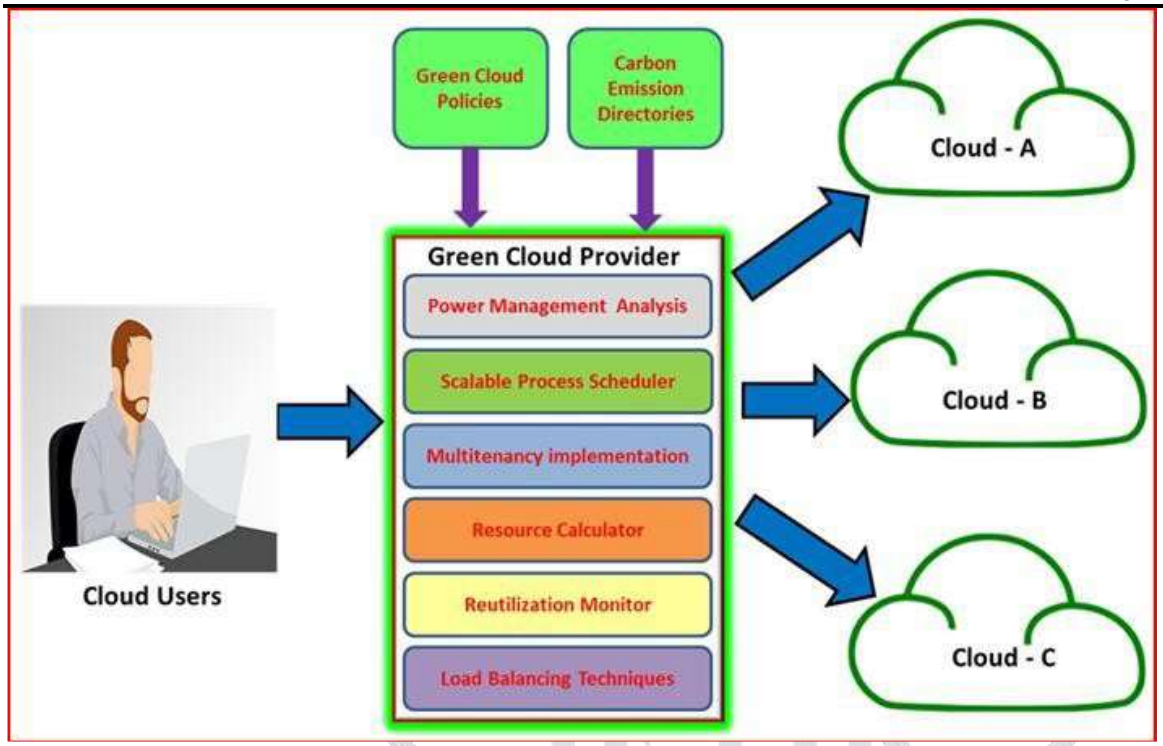

Fig. 2- Green Cloud Computing Architecture

Green cloud computing aims on designing the cloud environment as eco-friendly means the cloud should not exploit the greenness of the nature in any way. For example, a cloud environment is strictly following the energy efficient power management standards and policies to save the power, but it relies on coal based thermal stations for power supply, leads to an indirect damage to the nature. Hence the green cloud policies and standards must be designed by considering the direct and indirect negative impacts of clouds on ecology. Apart from the policies and standards, a set of monitoring tools and technologies are required to design the green cloud architecture. Figure 2 presents the essential tools and technologies used to design the green cloud computing architecture.

Aforementioned green cloud computing architecture designed with the Cloud Data Centres (i.e. cloud-A, Cloud-B and Cloud-C), Green Cloud Provider and Cloud Users etc. Cloud data centres are the standard cloud environments, designed to offer the cloud services like IaaS, PaaS or SaaS etc.The Green Cloud Provider (GCP) designed as a cloud service broker module, which is an authenticated module and allowed to monitor the cloud infrastructure and activities to certify the associated clouds as green. As part of its job GCP monitors the power management at each cloud level, by installing the module level energy consumption meters. After receiving the power consumption information from monitors, GCP analyses the consumption details with analytics and suggests the energy efficient power management solutions. Scalable process scheduler creates the virtual instances of cloud at run time to process the incoming request with high speed and accuracy. These virtual instances are used to enhance the ability of hardware infrastructure by utilizing them at max possible level. Custom job scheduling algorithms are used in this process scheduling for enabling the parallel processing. Apart from few notable big organizations, the other cloud clients are belongs to small or medium scale industries. They are unable to set up their own IT Infrastructure with huge capital investments; hence they are approaching the clouds to deploy their applications for storing and processing their data. In this case, the public clouds must be designed securely, to support a pool of cloud users to host their applications on common cloud instance and sharing the cloud resources among them. This process is called as Multi Tenancy in cloud computing.GCP module having resource calculator is another important cloud monitoring tool, which is deployed at each cloud instance level to record the utilization values of memory, CPU, Storage, bandwidth and time. This recorded information will be analysed, using the respective resource calculation algorithms to assess the future resources demand, resources underutilization, resources availability etc. Reutilization monitor is a high level examiner designed to propose the possible reutilization options of cloud resources to save the time and cost. Similarly the load balancing module concentrates on balancing the load (of Memory and CPU) across the multiple cloud instances while processing data to assure the smooth processing. Green cloud policies and carbon emission directories are the third party policy preparation groups. Their designed policies and standards help to construct the green clouds from normal cloud environments. Finally the end user is an IT manager of any organization, who can communicates with GCP to discuss about hosting their organization applications on green

cloud and he plans the migration process of their IT applications with green clouds based on service level agreements (SLA).

2. Literature Review

As part of our research analysis on "Green Cloud Computing", we thoroughly verified many journals, conferences, white papers, web sources to get the extreme valid content about green cloud computing and its characteristics. In this section we present the literature review on green cloud computing with the help of its relevant former research publications. Each notable research activities in the area green cloud computing are explored in brief with author details. This information helps the naïve research scholars to understand about the evaluation of green cloud computing and the improvements it had since beginning.

John Judge at el (John Judge, Jack P, Anand E & Sachin Dixit, 2008) published a white paper on energy efficiency, to explain how to reduce the power consumption of data centers without effecting on the server performance and availability. Finally he suggested that the utilization of possible low voltage resistant processors, deployment of power management tools (to monitor and auto management of power), virtualization techniques (to increase the processing power with same resources), design of blade servers and efficient cooling mechanisms are the best practices to design energy efficient clouds.

Eduardo (Pinheiro Eduardo, Bianchini Ricardo et al, 2001) published an article on implementing the load balancing and unbalancing techniques in cluster based systems, to reduce the power consumption and to improve the processing speed. They designed the cluster based system with an "on & off mechanism" to automate the turn on and the turn off operations based on the need of power. At server level and the operating system level this mechanism was implemented and recorded the good results in resources optimization.

In 2010 Dzmitry (D. Kliazovich, P. Bouvry, Y. Audzevich & S. U. Khan, 2010) designed an NS-2 based simulator to record the power consumption at green cloud data centers. He performed some experiments with that simulator to record the power consumption values of cloud with Intel Xeon 4-core processor, 8MB DDR3 RAM and the 3.33GHz of cache value. They simulated and monitored the servers, routers, links, switches and workloads to determine the power consumption at each entity level. This simulation environment collected different cloud components related important power consumption statistics like extreme high/ low power usage values at each component, component idle state power usage, component average power usage etc. From their simulations we noticed the different cloud components consuming energy values are: CPU-130W (43%), Memory – 36W (12%), Disks-12W (4%), Peripheral-50W (17%), MotherBoard-25W (8%) and others – 48W (16%).

Green Peace International organization projected "ICT electricity consumption and Carbon Emissions by 2020" survey report (Green Peace International article, 2010), specified that both the Electricity consumption and Carbon Emissions will record the annual growth rate between 9 - 9.6%.They outlined the three key factors about the health of present clouds are: i) Clouds are expanding but not helping the economic growth of provider as expected, ii) highly concentrating on energy efficient cloud data centers design and iii) Popular cloud providers are constructing the extreme big data centers to tackle the competitors. In other side, this green peace article is shooting some key questions to the data center owners to support the green IT are: High Energy consumptions, Carbon emissions, Energy production sources (wind, hydraulic, coal, nuclear etc.) and efficient resource management etc.After the entire analysis on green cloud computing, we notified that the important four pillars of green clouds are energy efficiency, scalable resource management, low operating costs and environment friendliness.

3. Present of Green Cloud Computing

Green Cloud Computing is a win-win model between the cloud service provider and the environment. Green cloud not only beneficial to the environment,it also increases the profits of service provider by utilizing the resources efficiently. By insisting some management policies and characteristics in the existed cloud environment, we can make them as green certified clouds. There are growing numbers of activists in the market trying to tend towards the green information technology (IT) despite the fact that IT Greenhouse Gas (GHG) Emission share is 2% of the total global GHG emission. For this reason of less emission, the term Green IT is now changing towards Greening by IT. This term means that IT should become a helping hand in reducing the GHG emission globally.

3.1 Green cloud Virtualization

Primary reduction in the energy consumption is shifting towards virtualization . The use of virtualization along with that of Cloud computing is vastly present in our lives and plays an important role regarding green computing concept. And so it will not be fair with the green technology to exclude it from discussing here. Efforts of moving to cloud and using computers or servers of others for your computing requirements rather than purchasing a dedicated

machine is considered a greener option in today's era . Similarly there are people shifting towards the virtualization concept whereby they virtualize their several computers or servers on a single physical machine and save their costs along with the energy to an amazingly noticeable amount . The move to cloud computing by Microsoft reduces from 30 to 90 percent per user the energy use and its carbon footprint. Microsoft also facilitates the hardware recycling and donation .

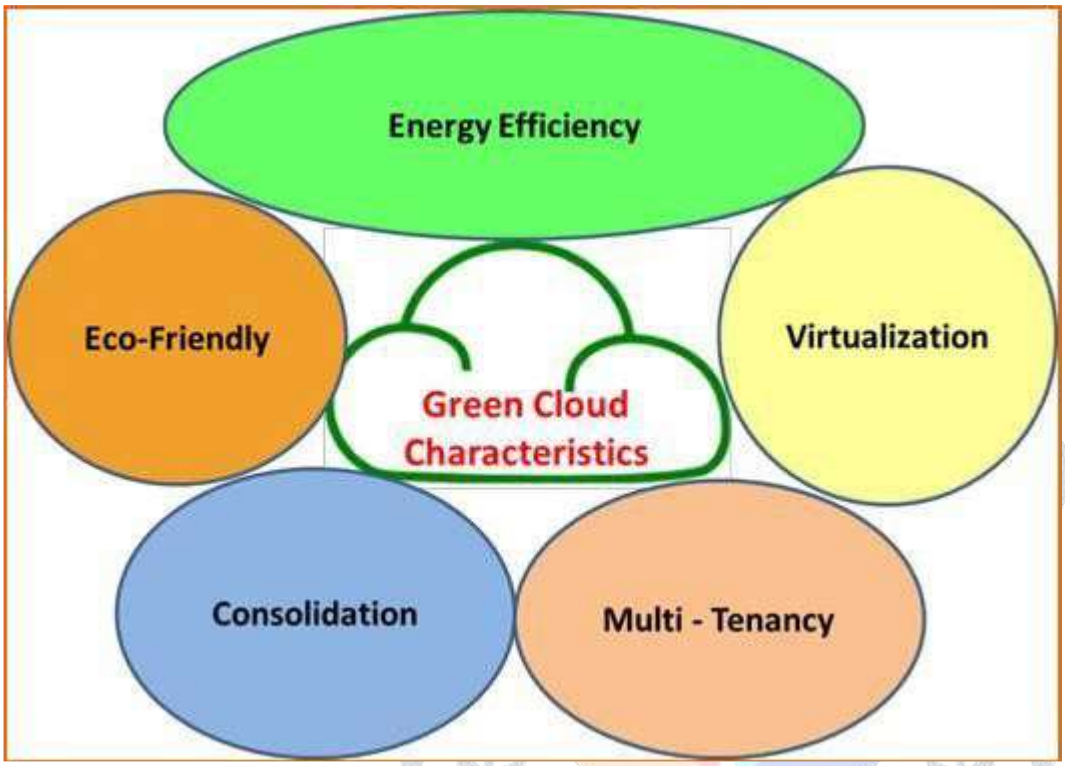

Fig. 3- Essential Characteristics of Green Cloud Computing

3.2 Energy Efficiency

The term energy efficiency is a basic building block of green cloud computing, which plays a vital role in construction of eco-friendly green clouds.Energy efficiency in cloud means, deploying the efficient power management techniques to reduce the power consumption at each cloud object (servers,data centers, disks, routers, processors etc.) level. Anton Beloglazov published a survey on energy efficient data centers and the cloud computation systems.

To avoid the unnecessary use of huge energy in cloud environment, recent researches (L. Benini, A. Bogliolo & G.D. Micheli, 2000 and D. Kliazovich & P. Bouvry, 2010) were proposed the dynamic power management (DPM) system. This system starts only the required cloud resources at beginning,estimates the power needs and supplies the adequate power voltage based on demand. If any cloud resource is supplied with the exceeded power (voltage),will be identified and corrected immediately using the dynamic power management techniques. This is called dynamic power optimization process.

Dynamic Power Management (DPM), working on power utilization monitoring tools, design of power utilization simulators, Decision making algorithms design in DPM, component level power management (resource power optimization) and creation of mixed work environments are the observed current trends in this area.

3.3 Multi Tenancy

Multi tenanacy refers to a software whereby a single instance of software application is served to multiple users.Each user is called a tenant.In a multi tenancy each tenant is integrated physically but separated logically. Most of the times, multi tenancy became as a controversial topic in news on cloud, due to some privacy and security issues (R. Ashalatha & J. Agarkhed, 2016) involved in its implementation. NIST (Peter Mell and Tim Grance,2011) recognized the multi-tenancy as a main characteristic of green cloud because it helps widely to save the resources by hosting multiple tenants with one cloud instance. Cloud Security Alliance (CSA) also defined the multi-tenancy (CSAguide.v3.0) as an important corner pillar of green cloud. Most of the times the concept multi tenancy is hard to understand by the listeners and beginners of the cloud, because it is implemented at two layers of cloud are SaaS and PaaS. At SaaS level the deployed application resources are shared among multiple tenants, i.e. SaaS contained the

line-of-business category applications like SalesForce CRM, which is a single instance but offering its services to several organizations. Each customer is belongs to a separate organization but all customers are storing their data in same database tables offered by the CRM application. At PaaS level the term multi tenancy means, implementing the resource sharing process with cloud infrastructure hardware (Processor, Disk, RAM etc.) and software (virtual machines) across multiple clients to reduce the processing cost and to optimize the resource utilization. Secured Multi-Tenancy development, Multi Tenancy Optimizations, Privacy preserved secure access to multi-tenancy clouds are the trending developments in this green cloud research area.

3.4 Consolidation

The concept consolidation means "the process of deploying different data centers related data processing applications on a single server with virtualization technology". This is the main sub task derived from virtualization and it is committed to implement the process level load balancing, better utilization of virtual systems and reducing the power consumption also. Anton Beloglazov et al (Anton Beloglazov & Rajkumar Buyya, 2012) thoroughly discussed about the need of consolidation, the procedure of dynamic consolidation of virtual machines and the advantages in detail. They explained about how to consolidate a single physical server with multiple virtual machines (one - many approach), and multiple physical servers with multiple machines (many - many approach). They proposed Online deterministic and non-deterministic algorithms to explain the process of VM's migration in cloud. In another research paper (Anton Beloglazov & Rajkumar Buyya, 2010) they proposed a threshold based approach for IaaS platform, to perform the VM's consolidation to balance the load efficiently and to avoid the resource underutilization problems. Apart from their former approaches based on threshold value, they also introduced the determination of threshold value dynamically, based on the present VM's need and their historic usage statistics.Scholar Hosseini raised the live problems while he is doing the virtual machines consolidation process (Mirsaeid Shirvani, Amir Rahmani & Amir Sahafi, 2018). The consolidation process is resource incentive and expects the intelligence support to reduce the server down time to a minimum. To overcome the consolidation process live problems limitations, he proposed DVFS (Dynamic Voltage Frequency Scaling) based virtual machines consolidation technique, to save the energy by running the servers at different voltage frequencies. Dynamic consolidation, Threshold based consolidation,optimization of consolidation process are the present trending topics in green cloud virtual machine consolidation.

3.5 Environment Friendly

Green cloud computing often rely on renewable energy sources,making them environmentally friendly. Green Computing proposed ecofriendliness bridges the gap between economy and environment using the cross cutting technologies. The term green cloud computing implies that the green clouds are environment friendly clouds, which are especially designed to minimize the environment spoiling activities (in the name of development)and ensures the non-disturbance to ecology elements. In this paper, we mostly discussed about the energy efficiency in all the way, because if we save the power means we reduced the need of power production, which helps in regulating the dioxide omissions to environment. Today energy sector is highly depending on Coal-based power generation and Nuclear-reactors based power generation systems, which releases the harmful monoxides to the environment to fulfil our energy needs.Major IT companies have taken note and are switching the majority of their data centers onto renewable energy sources. Amazon,google and Facebook are just a few companies who have made great efforts to be environmentally friendly and set ecological company goals.

4. Future of Green Cloud Computing

Energy Efficiency: As the today clouds are designing with the multi-core CPU's, there is a need of designing the power optimization and management techniques to support the power management with multi-core CPU's. Another huge power consuming part of cloud is the data center, which is a collection of data storage components and data management software. An efficient power consumption monitoring system, dynamic powermanagement system and intelligent power supply decision making systems are the research challenges in this area. By considering the today pace of IT, we need a comprehensive and intelligent mechanism to tackle with the entire cloud architecture level energy optimization issues.

Virtualization: Many former researches were widely concentrated on designing of the efficient cloud virtualization process, but the virtualization is still suffering from some high-end optimization relevant limitations. Designing the novel methodologies with the state-of-the-art technologies to optimize the entire lifecycle of virtualization process is an important research challenge (Tadapaneni, N. R., 2018). Automated optimal VM's creation with substantial resources and dynamic resource allocation & sharing facilities without affecting the cloud performance are the other considerable research challenges in virtualization.

Multi- Tenancy: Although this an essential character of green cloud, at present multi tenancy is suffering from the privacy and security concerns. Designing the secured multi-tenant architectures and privacy-preserved secured access to multi-tenant modules are the considerable future research challenges.

Consolidation: Design of intelligence support in VM's consolidation, Multi aspect based threshold value calculation, leveraging the key resources and server downtime management became the future research challenges in this area.

Eco-Friendly: This area mainly concentrates on environment based tools design i.e. carbon emission calculator tools to measure the effect of the cloud on nature. Need to design of a comprehensive framework to certify the clouds with ranking, based on multiple aspects of Green Cloud Computing.

5.Conclusion

Our research analysis on green cloud computing, in this paper we presented the literature review on green cloud computing. At glance we briefly explored the concept cloud computing and the need of designing the green clouds. Literature review presented the former scholars conducted researches on green clouds, their research identified limitations and proposed solutions. We presented the green cloud computing architecture with respective modules in detail. This paper mainly focused on exploring the notable characteristics of green cloud computing with past research discussions, present trends and future research challenges. This paper is designed by authors as a minified guide to green
cloud research scholars to understand about the green cloud computing characteristics, its current trends and future research challenges.

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