SUSTAINIBILITY OF CLOUD TECHNOLOGIES UNDER GREEN COMPLIANCES

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***Abstract*— E-commerce transactions with high speed internet has rapidly increased traffic and workloads on computation infrastructures. The frequency of online activities is astronomical if we analyze queries made by each customer on a website for a concurrent e-commerce transactions on per day basis. Thus, for meeting this huge requirement one would require to have well designed infrastructure that can handle energy, memory and internet related requirements with fault tolerance with its associated data centre on large scale. MNC giants like eBay, Google, Amazon owns such infrastructures along with large scale data centers across the globe. When we can provide services related to such advancements in market, we term it as Cloud computing. Under Information & Communication Technologies (ICT) category, Cloud computing is progressively moving towards making it a sustainable and environmental friendly platform. Due to its immense utilization on large scale physical infrastructures, Cloud Computing is one of a dynamic technology that requires potential improvements related to its future implementation. The economics of this technology is highly acknowledged in terms of profit margin as well as in power consumption. Virtual technology hosted on physical infrastructure of servers act as base of Cloud services and can be optimized to reduce power consumptions. On the other hand, such facility might grow users at greater volumes which thereby would increase the need of data management techniques and can hamper power savings.**

***Index Terms*— Green Cloud, Energy Efficiency, Virtualization, Sustainable Technologies.**

I. OVERVIEW

A typical datacenter with 1000 racks need 10 Megawatt of power to operate, thus the overhead expense increases for managing the usage. Ideally for a datacenter, power related cost should be less than managerial cost. Moreover, in April 2007, Gartner estimated that the Information and Communication Technologies (ICT) industry generates about 2% of the total global CO2 emissions, which is equal to the aviation industry [1].

As an alarming requirement posted by European Union in a report, current technologies are expected to reduce power consumption in between 15%–30% so as to bring global temperature of earth down by 2 C till year 2020. From the environmental point of view, carbon emissions from power houses has become crucial for Cloud infrastructures. Techniques such as load balancing and platform virtualization have proved to be very effective in reducing energy requirements by Cloud computing in comparison to other data based technologies in market. What really waste energies in data centers are those dynamic software that are configured to give high performance on the cost of optimized solutions.

If we have dedicated datacenter for Cloud services we can decrease power requirements through load balancing techniques and server based optimizations. This include variety of computational styles where host can be shared using virtual technologies. Thus those nodes that are not utilized can be powered off to save energy. A recent research by Accenture [2] shows that moving business applications to Cloud can reduce carbon footprint of organizations.

Due to less utilization tech based startups that uses cloud based services can contribute in saving energy and power requirements at enormous level being 90% of it. Because startup companies will then not require any dedicated hosting and cloud services can be utilized on shared basis for different vendors, the overall utilization increases. Utilization of Cloud based services in MNC world too can reduce power related rating by 30-60 percent. Middle scale companies can decrease it by 60-90 percent.

Greenpeace [3], observe that the Cloud phenomenon may aggravate the problem of carbon emissions and global warming. Overall requirements with Cloud Infrastructure is predicted to grow with the advent of time. Thus scalable data centers will be required to meet necessities by growing demands. In doing so again power consumption pattern will be increasingly important to be studied so that we can reduce harmful CO2 emissions through various techniques. Carbon emissions are directly proportional to the consumption of electricity energy by Cloud Vendors. When we analyze the energy pattern in Table below we can see that present data centers are far away from making itself under "Green" technology. Due to flexible nature of Cloud Technologies that is constitute of scalability, reliability and security with high performance at economical price, cloud computing has been able to brought revolution from designing physical networking again along with being responsible for making it sustainable

from environmental point of view. Apart from reducing expenses and improving utilization of resources Cloud based services mainly focuses about increasing energy efficiency of its infrastructure which thereby can decrease carbon footprints. Such paradigms help to infer and turn existing cloud platform into green cloud. We can highlight certain green aspects of Cloud technologies through a survey based reviews.
Sustainability has been gaining importance among software and hardware developers and users in the last two decades, due to the rapid growth in energy consumption.

Impact of information and communication technologies (ICTs) against environment has to be carefully examine at various levels. To motivate eco friendly and green technologies for future data centers, research in this direction is particularly is required that can upgrade existing cloud systems that are not adhering to green standards. From past ten years, there has been a constant stress over improving energy consumption all over. Using awareness campaigns and support, corporate world is been persuaded towards bringing their infrastructure in compliance with eco-friendliness as mandatory regulations. Researchers hence are required to develop such products and services that can reduce negative outcomes on the environment. Certain terms related to ICTs such as green computing, ecology informatics, etc comes under green parameter.

II. RELATED CASE STUDIES

According to Hilty et al. [4], the decisions made with regard to the sustainable development of ICTs and the relation between these two fields must consider the positive and negative influences of ICTs on the environment both in the present and in the future.

One of the common factor that is found to cause neglection of eco-friendliness is glamour related with the technologies by both service providers and the customers. Commitment is required at both ends along with sense of responsibility by users and producers to promote and support the international environmental organizations. Such firmness can move the statistics in favor for the usage of ICTs under green and eco friendly regulations. In order to save our ecosystem, keeping a watch is of utmost importance here too. Still implementation path of sustainable ICT's gets hurdled due to factors like overhead expenses, required time of implementation, strategic challenges, absence of sense of responsibility, internal problems within organizations, lack of government aids etc.

ICT is super set for Cloud computing technology, is closely related to subject of environment these days for research. Debate between different prospect of ideas continues to develop these technologies in more environmental friendly fashion. The ways in which existing ecosystem might get disturbed should be proactively researched so that necessarily regulatory decisions can be imposed by government on cloud based service providers.

Development with data centers with regard to Green Regulations directly impacts evolution of green cloud computing . This is because the primary power consumer of whole infrastructure is data center by any cloud vendor. According to Koomey [5], the energy consumed by data centers in 2010 represented 1.3% of the total consumption. A report published by GeSI [6], which is considered "one of the most comprehensive and well-recognized snapshots of the Internet's energy demand at the global level", estimates an increase in the share of total carbon dioxide (CO2) emissions from ICTs from 1.3% of global emissions in 2002 to 2.3% in 2020.

A tool CLEER (Cloud Energy and Emissions Research Model) was developed by a team of scholars at Lawrence Berkeley National Laboratory and Northwestern University related to power consumption by cloud computation technology. It was a modeling tool to compute the power economics while running an application on a local server to perform relocation task of data to other farms of server. Such cluster of servers develops into a cloud platform. One of the research calculated carbon footprints due to mundane tasks such as email, application maintenance and CRM based software can be decreased by 87%, if there is a will to shift customers to cloud infrastructure. Even if the model does not take into account all the variables, it can prove useful in leading to energetic efficiency in the data centers which belong to Internet companies. [7]

Thus we can facilitate choice to users about energy transparency which can make them aware about potential outcomes of the choice they will be going to make. To realize more advantages alongside with green cloud using data centers of latest technology, one need to study resource utilization pattern and computation time followed by green infrastructure that uses load balancing techniques.

III. ENERGY EFFICIENT INFRASTRUCTURE

The operational patterns of data centers suggest green strategies to cut energy costs and overhead expenses. This motivates potential investors to count on more to Cloud vendors in making them accept best practices in turning their infra into green. Starting from Processor level to Data Center level, developing an eco-friendly data storage infrastructure requires lot of commitment and several analysis which can propose performance related improvements. Initial step towards development of any cloud based infrastructure should be optimized architecture of data center. That infer out two major factors affecting green ICT's is power supply sources and other is high performing devices.

Eco-friendly designs of data centers constitutes of utilizing natural power resources like solar and wind energies for electricity generation. As per the theory, energy is never created nor destroyed but can be transformed. Location of data centre also plays crucial role in saving power requirements that are directly related to climate, ease of accessibility to power

sources, fiber cables etc. From the commercial point of view, energy sources are always sought by cloud vendors in terms of expense related to them and not for carbon footprints. This shift of interest is in the hands of government to push with regulations that encourages the later perception. At least one third of the total power requirement is shared by cooling systems in data centers which is one of the much demanded area of research. Some research studies [8][9] have shown that uneven temperature within datacenter can also lead significant decline in reliability of IT systems. The two best techniques for data centers regarding cooling are based on air and water as resources. The final requirement is to cool down heated devices and there is no need to cool whole surroundings of equipments. This strategy saves lots of unwanted power consumption in cloud based infrastructures of large scale,. Latest innovation in this direction is using liquid cooling, nano fluid-cooling systems. Some companies like Spray cool are dedicatedly working towards providing cooling services to server based systems with in-rack/in-row designs. We cannot also neglect the impact of surrounding temperature where physical equipments of data centers are kept that reduces cooling requirements. Some systems have been constructed where external cool air is used to remove heat from the datacenter [10].

Going more deeper into technology for data centers, performance and utilization index could be improved with power saving processors and servers implanted in them. Processors too have proved to improve electricity savings at larger scale in Cloud systems. Corporate giants like Intel, AMD who are pioneers in the field of processor designing and manufacturing have released various power saving servers in market offering noticeable performance/watt results. Also in server various practices like slowing CPU clock cycles, or switching off components of the chips while they are idle helps in cutting power requirements. The announcement of multicore technology has aided more in electricity saving and improvement in performance of computing per watt.

As an example a multicore chip from Suns, consist of 32 thread Niagara chip, UltraSPARC 1, which utilizes approximately 60 watts. On the other hand two Niagara chips would contain 64 threads to consume about 80 watts for execution. However, the exploitation of such power efficiency of multi-core system requires software which can run on multi-CPU environment. Here, virtualization technologies play an important role. ICT's with advancement in storage services in distributed fashion can aid in saving electricity related necessities. Teradata brought revolutionary technology with best Storage Area Networks (SAN) in world. Overall performance was improved with the technique of consolidating the storage and disks with Solid-State, SAS etc. quality in bringing energy efficiency further.

Another energy efficient module to be inculcated in data centre include the use of eco-friendly sources to cloud infrastructure that consumes electricity. Its responsibility would be to act as power source by transforming itself into low voltage Direct Current that is required by most of the devices from high-voltage alternating current power grids. As an unwanted by-product, heat energy gets generated due to underlying wiring in Power Supply Unit (PSU) and is expelled out through internally implanted extra fans in PSU. Performance and utilization index of a PSU is directly proportional to the load it is going to bear. Quantity of circuits and external factors like climate also alters energy efficiency. Thus would be misleading to say about any such PSU offering 90% utilization for certain load would not continue to give same performance with different power loads. Apparently energy efficient PSU could be dealing only with low power loads and creating a wrong impression in reality. For example, PSU could be only 70% efficient at 30% of power load. According to a research PSU were found to be culprit components in energy saving data centers. Since mainstream servers are being delivered with as much as 60 to 70 percent efficiency even today. A solution to this can be practiced by the use of ENERGY STAR certified equipments. Such certificate is issued to only those PSU which is offering a minimum of 80% energy savings at worst case of power load.

Energy consumption can be further reduced by power saving network level components at node level i.e. NIC or at compete infrastructure level i.e. routers. The term "Green Networking" is used when eco-friendly designs are implanted at network level to physical devices or software algorithms governing the networks.

Various category of solutions are available for energy efficiency at this point with etymology as:

- Resource consolidation
- Virtualization
- Selective connectedness
- Proportional computing.

IV. CONSTRUCTION OF GREEN CLOUD PLATFORM

Construction of green cloud include an innovative middleware named as Green Broker to carry out processing work related to services asked by users through Cloud and administer the allocation of cloud provider with least energy requirements as greenest Cloud provider. There are mainly three types in which we can divide a request made by users:

- Software
- Platform
- Infrastructure

Green offers can be promoted on public platform in the form of repository where Cloud vendors can formally issue their schemes through Green Broker. With a concern to keep carbon emissions on minimum levels such green offers are mostly tailored in providing services with eco friendliness, less expensive and time consuming. A repository could be a simple directory where Green Broker can track the arguments related to usage of Cloud services and carbon emissions for overall energy consumption.

We can call it Carbon Emission Directory where data related to efficient usage of cloud services can be stored and managed. Such directory could contain data about PUE as well as cooling systems available with the Cloud datacenter followed by network overheads and rate at which carbon emission took place as per energy consumption. On infrastructure level carbon emission gets calculated by Green Broker for registered Cloud vendors with that data center who get potential cloud requests for service. Green broker then make a group of such services that gives minimum carbon emissions and purchase it for users.

Green Cloud as simulation platform takes care of all reporting and monitoring of data related to energy consumption by user for various tasks on cloud infrastructure. To do so, the framework make use of two repositories namely:

- Carbon Emission Directory
- Green Cloud offers

Cloud vendors are motivated to keep their services 'Green' since their energy efficiency gets traced through these repositories and concerning body may also reward those vendors that provide their service under "Green" compliance. To guarantee carbon emissions with least possible values as one of prime QoS asked by users, Green Broker is assigned important responsibility for tracking and picking the best Cloud services. Hence the pick and choose procedure followed by user for accessing Cloud services in the form of SaaS, PaaS or IaaS should be green too. Or we can say Green Broker needs to be "Geen" conscious for every level of processing requirements.

V. CONCLUSION AND FUTURE SCOPE

To keep increasing cloud based demands and energy consumption in balance, green technologies draws the line of control for future. Based on various dedicated researches done towards minimizing energy requirements by data centres so that Cloud vendors can attain considerable profit margins in comparison to existing technologies. Today there are available technologies that supports multitasking with eco friendliness within data centres hence Cloud Computation yields minimum carbon emissions as energy consumption is reduced. 'Virtualization' technique is responsible for significantly reducing energy consumption and improving energy efficiency for Cloud vendors through less costly service models targeted to meet large scale demands with number of different companies sharing the same infrastructure. Virtualization is the process of presenting a logical grouping or subset of computing resources so that they can be accessed in ways that give benefits over the original configuration [11]. Also energy consumption is reduced by grouping those servers who are less frequently used and bring them on virtual platform on shared basis, thereby making it highly utilized resource. Organizations thus get benefited by saving memory space, compute operations, and power. Such characteristics of Cloud technology helps in decreasing overall power requirements by 30% where one can transfer software on Cloud platform. On large scale implementation such energy reducing techniques proves very effective in making large scale savings through Green data centers and Green consciousness.

• Dynamic Provisioning: When utilization rate of resources are at peak i.e. the capacity are at the verge of getting saturated to meet computation demands on networking infrastructure, traditional technologies cannot handle the system. One of the solution companies tries to implant is adding more infrastructure to existing ones. This makes system over-provisioned and also cost of overheads increases with following challenges:

a) The extra infrastructure may remain powered on and unutilized for a longer period of time because we cannot predict the demand for example internet based websites that are of dynamic nature are susceptible to such situations.

b) Quality of service is to be guaranteed as availability time to users should not be compromised which upgrading systems.

One example of a Web service facing these problems is a Website for the Australian Open Tennis Championship. During tournament season Australian website which is publically visible gets a marginal shift on load level annually. The increase in traffic can amount to over 100 times its typical volume (22 million visits in a couple of weeks) [12]. In this situation, we can observe that the for a temporary amount of time system requirements exceeds the servicing capacity. It is not wise to maintain extra infrastructure for whole year when it is required only during tournament as it is used only to manage hike of computation load. From the energy conservation point of view also this is not eco friendly solution either. Hence the idea of adding extra resources is not giving proper utilization index. In such situation we need a dynamic solution and there is no match other than subscribing to a cloud infrastructure. Whenever there is extra need of resources, the virtual appliance running on Cloud platform can be dynamically moved to another available server to meet growing demands. Allocation of Cloud resources can be also managed as per demand since resource provider here keeps monitoring the availability and can predict the best solution. Consolidation of resources within same server can be done for those jobs that dont require much resources. Data centers are required to keep its servers powered on always, however it is still much energy conservative solution than the traditional idea of over-provisioning by individual companies.

• Multi-tenancy: When many operations can be performed on single infrastructure we name it multi-tenancy. In Cloud based systems this feature helps in saving lots of power utilization thereby reducing carbon emissions through it. Many vendors at a time can be equipped with cloud services for giving respective SaaS. Had there been as many infrastructure as many softwares in market the energy consumption by them would be that many times. Cloud here proves to be best approach for conservation of energy on large scale. Even if certain businesses expect to receive highly variable demand

patterns on their ends the multi-tenancy characteristic of cloud server aids in managing the hike of demand and companies are saved from the idea of over-provisioning themselves. Although if the demand pattern is slightly changing we have improved predictions with increased power savings.

• Server Utilization: Average utilization of individual infrastructures are seen to go below 5 % which is too much low from energy conservation point of view. The use of virtual technology in such cases where more than one software can be transparently hosted on single infrastructure, improves utilization rate to 70%. On cloud platform, we can actually save multiple servers from getting powered on. When server utilization rate increases, the computation involved in doing so also increases power consumption. However many non-cloud servers running with high utilization rate would be doing similar power usage multiple times.

• Datacenter Efficiency: We have talked in previous about role of data center as individual in bringing eco friendliness and green compliance to its infrastructure design. The impact on overall energy requirement is created by using Cloud computing by bringing energy efficiency . Although cloud vendors tries to serve best available energy efficient technologies with least value of PUE by their datacenter, latest designs of data center specially tailored for Cloud technologies can further reduce PUE to 1.1 to 1.2, hence improving the energy utilization by 40% as compared to traditional data centers. Other techniques such as load balancing, advanced power sourcing, cooling systems in designing data centers with modular architecture further helps in decreasing PUE values. Virtualization also provide flexibility of transferring appliances with Cloud platform from one data center to other in dynamic manner without making any impact on up-time of servers with considerably lower PUE values. Latest available high speed network, energy efficient equipments, cloud based measurement, tracking and reporting of modern data center aids in making it Green technology.

As a combined scenario we can say there is huge scope of improvement in making cloud based systems more energy efficient although there have been immense research done to do it already in terms of hardware and software optimizations. Currently the sustainability of Cloud based systems gets leaked on network level due to lack of advancements in its researches. As the file size increases its transfer operation will consume excess of energy on network level and best solution is to perform data local processing than to bring such files on cloud for computation. In practical world much of the focus by companies remain limited to specific module of Cloud platform and much of the other areas are missed that can potentially influence total power consumption. As an example, when we try to concentrate computation on less number of servers through VM consolidation, we are only focusing about decreasing number of active servers and ignoring the fact that workload in concentrated manner create excessive heat dissipation issues in infrastructure that demands cooling overheads. In other cases it has been also observed that if one tries to apply load balancing technique on cloud platform in distributed manner to reduce heat dissipation by single node here the side effect of virtualization gets missed. Business agencies only tends to apply profit oriented schemes and does not generally adapt to proper solutions that aids in making cloud infrastructure Green and energy efficient to optimize carbon emissions. Hence there is a need of developing a one stop sustainable solution in support for Green Cloud computing.

REFERENCES

[1] Rivoire, S., Shah, M. A., Ranganathan, P., and Kozyrakis, C. 2007. Joulesort: a balanced energy-efficiency benchmark, Proceedings of the 2007 ACM SIGMOD International Conference on Management of Data, NY, USA.

[2] Accenture Microsoft Report. 2010. Cloud computing and Sustainability: The Environmental Benefits of Moving to the Cloud.

[3] Greenpeace International. 2010. Make IT Green

[4] Hilty, M.L.; Arnfalk, P.; Erdmann, L.; Goodman, J.; Lehmann, M.;Wager, A.P. The relevance of information and communication technologies for environmental sustainability—A prospective simulation study. Environ. Model. Softw. 2006, 21, 1618–1629.

[5] Koomey, J. Growth in Data Center Electricity Use 2005 to 2010. 2011.

[6] GeSI. GeSI SMARTer 2020: The Role of ICT in Driving a Sustainable Future. 2013.

[7] Masanet, E.; Shehabi, A.; Ramakrishnan, L.; Liang, J.; Ma, X.; Walker, B.; Hendrix, V.; Mantha, P. The Energy Efficiency Potential of Cloud-Based Software: A U.S. Case Study. 2013.

[8] Ranganathan P, 2010, Recipe for efficiency: principles of power-aware computing. Communication. ACM, 53(4):60–67.

[9] Moore, J. D., Chase, J. S., and Ranganathan, P. 2006. Weatherman: Automated, online and predictive thermal mapping and management for datacenters, Proceedings of the 3rd International Conference on Autonomic computing, Dublin, Ireland.

[10] Woods, A. 2010. Cooling the data center. Communications of the ACM, 53(4):36-42.

[11] Smith, J. and Nair, R. 2003. Virtual Machines: Versatile Platforms for Systems and Processes. Morgan Kaufmann: Los Altos, CA.

[12] IBM. 2008. "Take the tennis to 1.9 billion viewersworldwide? Done.," 04/05/08, 2008.