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Green Cloud Computing For Sme In Environmental Sustainability

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Abstract

The Mother Earth is under tremendous pressure. We the human being that may be in the form of governments, small or large enterprises and users, consumers become more responsible for this increasing pressure. Governments and businesses should play a major role, in invoking green wave for the sustainability of the environment. Consumers have shown increasing concern for the environment, but in many researchers proven that there is a green gap. This research describes a study that investigated the green gap amongst existing situation and the ideal phenomenon to determine possible causes for a lack of green behavior. Suggestion and recommendations are made to SMEs to encourage businesses in environmental sustainability.

Introduction

"Green IT is part of a fundamental change in the economy and society. It is a subset of the larger green (sustainable) business trend, which reconciles sustainable business practices with profitable business operations." Molla et al. (2011) defined green IT attitude as sentiment, norms, and values with relation to eco sustainability and role of IT. E sfahani et al. (2015) tested green IT attitude by measuring the impact of argument quality, source credibility and green IT belief. By using value-belief-norm theory, Huijts et al. (2013) measured the predictive power of personal norms on pro-environment behaviour. Akman and Misra (2015) investigated on technology acceptance model to explain the attitude towards using green IT.

Cloud computing technology have a variety of application domains in terms of SAAS(Software as A Service), PAAS(Platform As a Service) and IAAS(Infrastructure As A Service), since they offer scalability, reliability and offer high performance at comparitively low cost. The cloud computing technology is restructuring modern networking, and also offering environmental protection prospects as well as economical and technological advantages.

The innovations in green cloud computing is directly related to the evolution of green data centers, as the data centers are base of the cloud computing. On the global scale, today data centers are poised to be the largest global energy users by 2025 at 4.5%, an increase from just 0.9% in 2015, according to Andrae's report [1]. According to the report published by GeSI [2], 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.

With the cloud computing and energy consumption aspects, a group of scholars at Lawrence Berkeley National Laboratory and Northwestern University proposed a modeling tool called the Cloud Energy and Emissions Research Model (CLEER). The model calculates and forecast the energy savings from transferring local network software and computing onto the server. These servers make up the cloud. The results calculated estimates that the primary energy footprint of email, productivity software and CRM software might be reduced by as much as 87% if all business users in the US shifted to cloud computing [3]. Even though the model has not taken all the variables in account, it has proven its usefulness is leading to energy efficiency in the data centers which belong to SMEs. The beneficiary use of cloud computing are more significant and effective for environmental protection if data centers are built on the concept of green computing principle. These technologies have the potential to reduce energy consumption and to reduce carbon footprints and (e-)waste. These features can turn a simple cloud computing environment into green cloud computing.

2. Overview of Cloud Computing

Cloud computing has become an important paradigm because it offers dynamic, high-capacity computing capabilities, including access to complex applications and data archiving, without requiring additional computing resources [4]. It uses cloud data centers through virtualization and hypervisor

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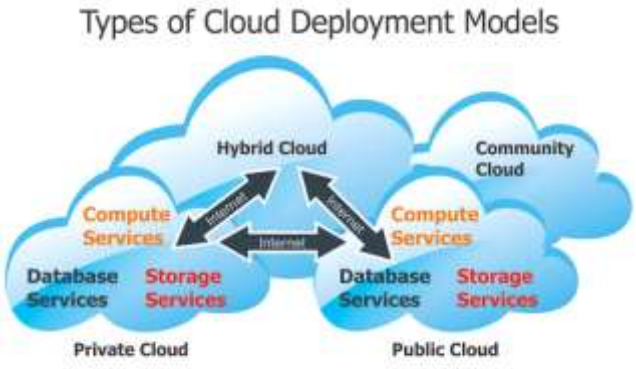
technologies to offer a powerful computer environment. The concept is developed and has gained the interest of many small and large scale business organizations, mainly due to the reduction in expenses by diminishing the investment in hardware and software. Cloud computing is "an old idea whose time has (finally) come" [5] (p. 2).Parallel computing, distributed computing, Service-Oriented Architecture (SOA), Microservice Architecture, grid computing, virtualization, and containerization are the basic concepts of cloud computing [6]. Cloud computing technological solutions are extremely dynamic and virtualized. They are continuously being improved both from the hardware and software perspectives. According to Heininger [7], the listed keywords characterize ICT provisioning model offered by cloud computing: ubiquitous, service-centric, scalable, consumption-based and self-service. The National Institute of Standards and Technology (NIST) has presented RA cloud computing architecture as "a model for enabling convenient, on-demand network access to a shared and accessible pool of computing resources such as networks, servers, storage, applications, and services etc. that can be rapidly provisioned and released with minimal management effort or service provider interaction" [8] (p. 2). According to Buyya et al. [9] (p. 3) "a cloud is a type of parallel and distributed system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resource(s) based on service-level agreements established through negotiation between the service provider and consumers". Cloud computing configures existing technologies and architectures to optimize the use of software, platforms and infrastructural resources. There are main 3 service models as follows:



1) IaaS (Infrastructure as a Service)

2) PaaS (Platform as a Service),

3) SaaS (Software as a Service).

Figure 1. Types of cloud computing

IaaS and PaaS provide services to software vendors and developers, while SaaS provides services to end users. A cloud computing should consider the accessibility which can be ranked as private, public, hybrid, and/or community cloud.

According to Kliazovich et al. [10] (p. 2) and with regard to the topic of this paper, "from the energy efficiency perspective, a cloud computing data center can be defined as a pool of computing and communication resources organized in the way to transform the received power into computing or data transfer work to satisfy user demands". The definition refers to the energy efficiency characteristic of the IaaS model while SaaS provides benefits through centralization of processing environment and service sharing software and optimize data center functionality in order to use less equipments and infrastructural resources.

SaaS providers could offer green software services on green data centers with less replications that improve software energy efficiency without violating Service Level Agreements (SLAs). The cloud providers have larger set of resources than individual users.

In the case of PaaS, the providers could offer facilities such as green compilers, green softwares, green platforms through green cloud computing, both SaaS and PaaS methods and tools achieve software-level energy optimization. In interest of environment, the advantages of cloud computing are as follows:

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a) better strategies for energy efficiency, and reduced equipment requirements

b) lower CO2 emissions, with, consequently,

c) less e-waste.

3. Green Cloud Computing Trends with reference to SMEs :

Green Cloud Computing innovations help SMEs to deal environmental issues into their strategies in order to create or consolidate their competitive advantage. Green cloud computing is closely associated with eco friendly target achievement; therefore, green innovation is widely believed to stimulate environmental performance [11]. Green cloud computing product and process innovation not only reduce negative environmental impact, but they also increase the economic and social performance of a company through waste and cost eduction [12].

SMEs can implement green IT and Cloud Computing innovation in the manufacturing process to shorten production time, reduced costs and reduce waste. In addition, a good product innovation improves market position, affirms brand names, leapfrogs competition, creates breakthroughs, and attracts new customers [13]. The literature reviewed on the topic explore different context towards green cloud computing; words like Green IT, Green Softwar, Green hardware and eco-technologies are used indistinctly.

Driessen and Hillebrand apply "a rather pragmatic definition", stating that it "does not have to be developed with the goal of reducing the environmental burden. It does however, yield significant environmental benefits". One of the applicable definition, by Fussler and James [14] defines eco-innovations as "new products and processes which provide customer and business value but significantly decrease environmental impacts". In a similar manner, Kemp and Pearson ([15], p. 3) define eco-innovation as "the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives". Chen et al. (2006) define green innovation "as hardware or software innovation that is related to green products or processes, including the innovation in technologies that are involved in energy-saving, pollution-prevention, waste recycling, green product designs, or corporate environmental management".

4. characteristics of Green Cloud computing influencing SME's :

Lower CO2 emission is expected in Cloud computing because of highly energy efficient infrastructure and reduction in the IT architecture itself by multi-tenancy. The main driving technology for energy efficient Clouds Computing is "Virtualization," which allows significant improvement in Green IT efficiency of Cloud providers. Virtualization is the process of presenting a logical grouping of computing resources (Software, Platform and storages).

1. Dynamic Provisioning:

the infrastructure provisioned with a conservative approach results in unutilized resources. Such scenarios can be readily managed by Cloud infrastructure. The virtual machines in a Cloud infrastructure can be live migrated to another host in case user application requires more resources. Cloud providers monitor and predict the demand and thus allocate resources according to demand. Those applications that require less number of resources and allocation can be consolidated on the single server. Thus, datacenters always maintain the active servers count according to current demand, which leads low energy consumption than the conservative approach of over-provisioning.

2. Multi-tenancy:

Multi-tenancy is the core tenet of cloud computing. By using multi-tenancy(Multiusability) approach, Cloud computing infrastructure reduces overall energy usage and associated emissions of harmful gases and energy. The SaaS providers serve multiple companies and multiple users on same infrastructure and software. This approach is obviously more energy efficient than installing multiple copies of same software on different infrastructure. Multi-tenancy with the same server allows the flattening of peak demand which can minimize the need for additional infrastructure.

3. Server Utilization:

In general, on-premise infrastructure run with 5 to 10 percent of average utilization. Using virtualization technologies along with hypervisor, multiple tasks can be hosted and executed on the

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same server in isolation, thus increases utilization levels up to 70%. And thus reduces the number of active servers requirement. Higher utilization server can process more workload with similar power usage.

4. Datacenter Efficiency:

The power efficiency of datacenters has impacted most on the total energy usage of Cloud computing. By using the most energy efficient technologies, Green IT Cloud providers can efficiently reduce on the PUE of their datacenters. Big players of Cloud service providers can achieve PUE levels as low as 1.1 to 1.2, which is approximately 40% more power efficient than the traditional datacenters. The server design in the form of modular containers, water or air based cooling and advanced power management through optimization of power supply , are approaches improved PUE in datacenters. In addition, Cloud computing allows services to be moved between multiple datacenter which are running with better PUE values. This is achieved by using high speed network, virtualized services and measurement, and monitoring and accounting of datacenter.

Considering the different impact of different innovation types on companies' resources and capabilities and the different efforts required by different kinds of innovations, we used the green innovation landscape map to analyze the different sources of innovation development starting from the idea that a company's green innovation strategy should determine how the different typology of innovation fit into the company's strategy and the resources that should be allocated to each [13].

5. **Challenges and Future Research in area of SME:**

Software design and architecture is important factor in green cloud computing. Applications can improve energy efficiency and resource management in effective implementation. The implementation has to be dynamic: resources should be automatically added or destroyed based on server loading, traffic and utilization. Some of the open problems faced are: the dynamic allocation of resources and energy, the reduction in execution costs and time taken for execution by the tasks and the reduction in energy consumption.

A VM allocation strategy could reduce energy consumption, utilization and expenses. The virtualization can be improved by the migrating workload between machines between geographically distributed datacenters. The workloads could be concentrated in green cloud data centers.

The big problems here are: equally distributing the workload between energy efficient data centers, significantly in those datacenters which are based on renewable energy; reducing the number of physical servers and infrastructure but increasing the processing power increases the VM size reducing energy consumption.

Heating problem in cloud datacenters is one of the repeatedly faced problem. The problem could be solved by scheduling workload be performed based on thermal aspects along with the improved heat recirculation. Building datacenters in areas with free cooling resources is a non-technical solution.

"Non-technical aspects" refers to regulations regarding the environment, and the internal strategies and policies of the organization. There are two problems in this regard came forward as follows:

- **Environment Protection Issue :** All the Cloud Provides must adopt and apply strict environmental protection regulations.
- **cost of green cloud computing :** These costs are transferred from the cloud providers to the cloud customers through broker or direct will increase the price of services. Some cloud providers have already built datacenters in geographical areas where renewable energy sources are available or may become available during the operational stage. This will uplift the chances of reduced cost of cloud computing.

Conclusion

Implementation green cloud computing technologies at SMEs is highly vital for the future enhancements with cloud computing. The rapid growth in datacenters, because of the exponential growth of the cloud computing is the basic cause in increase in energy consumption its effect on the environment in terms of the carbon footprints. ***The Green Computing*** is the new way of executing procedures and processes to improve

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significance of the computing resources to reduce the hazardous environmental impact of their utilization. Green Cloud computing Architecture is leading towards these trends, not only to energy efficiency, but also a carbon emission aware concept, energy consumption and greener environment needs.

Among all SMEs, the information communication technology (ICT) industry is responsible for a worldwide growth in energy consumption. The major goal of green cloud computing is to promote the recyclability or biodegradability of waste products by reducing the use of hazardous materials.

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