Green Computing-An Environmentally Sustainable Modus Operandi

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Abstract—Green computing or Green IT is the latest research trend that deals with the efficient use of computing resources. In wider terms, it can be defined as the field of designing, manufacturing, using and discarding the computing resources in a way that is innocuous to the environment. Lately, Green Computing has proved to be an issue of paramount importance for the government and private organizations globally with the advent of pervasive computing. This new technique not only considers the processing performance but is also energy efficient, which is the need of the hour. The impetus behind this change has developed due to the enhanced levels of Global Warming, soaring computational needs for businesses, burdensome energy costs and increasing sense of international energy security. The main aim of this paper is to elucidate the need for Green Computing, its framework, approaches, applications and barriers to its adoption.

Keywords— Carbon Footprint, Energy Efficiency, E-Waste, Green Design, Green Disposal, Green IT, Green Manufacturing, Green use.

I. INTRODUCTION

The main aim of Green Computing is to maintain and improve the computing performance, reducing the energy needs and carbon footprint [1]. This term came into existence in 1992 by the U.S. Environmental Protection Agency launched by Energy Star. It was designed to promote energy efficient devices and technologies [5]. Since then many government and private organizations are continuously implementing standards and regulations to implement green technology. The revision of energy star program was done in the year 2006 [3], [4]. In 2008, recycling for old computers and other electronics was carried out in 26 US states. By 2010, the American Recovery and Reinvestment Act (ARRA) was brought into legislation to optimize hardware and software development and cooling techniques and improve power supply chain [5].

Green computing has been widely accepted as an emerging topic in IT management and is becoming more and more attractive among the IT organizations, suppliers, manufacturers and service providers. It focuses on several aspects like design, manufacture, power consumption and disposal for the computer based services. 60% of the total energy production is done using non-renewable resources like coal and natural gas [2]. Due to the soaring energy costs and awareness about the global climatic change, the IT businesses are in search of solutions to offset the soaring costs and to use the technology in an environmental friendly way. Power management is of prime importance for devices with limited energy source like tablets and smart phones that support diverse applications like gaming, internet browsing and so on. In this era of technology, there is a dire need for power conservation and management for such devices. Thus, it has become increasingly important for all the business organizations to fulfil their duties towards the environment and incorporate green techniques in their businesses to improve their market value.

II. RELATED WORK

The authors in [6] present an overview about the Green computing challenges in terms of changing power requirements for IT sector. This paper also deals with the general trends in technology and their green computing needs. In [7], Xiaodan et al. discusses about a Green computing evaluation system using fuzzy synthetic estimation technique. The authors in [8] have compared the AMD and Intel processors in terms of Green technology and given its advantages and disadvantages. In [9], the authors discuss using Ant Colony System to Consolidate Virtual Machines for Green Cloud Computing and maintain the quality of data centers. In [10], the authors discuss the current approaches of Green computing in Malaysian IT sector. In [11], authors discuss the parameters for green computing using analytical hierarchy process. This paper deals with recycling techniques for electrical and electronic waste. In [12], the authors discuss different approaches to Green computing and their applications. In [13], the authors discuss about the Green Wireless networks and their fundamental issues. In [14], the authors have discussed the Green Computing evaluation process and its recent implementations. In [15], the authors have discussed about the approaches to Green computing and their effects on the environment.

III. NEED FOR GREEN COMPUTING

The IT industry and its computer solutions have revolutionized our lifestyle. We have astounding software and hardware solutions to fulfil our needs and make our lives easier and smoother. Such solutions require more processing capabilities like power and speed. This has increased the emission of greenhouse gases and enhanced the pollution levels. Huge data centres require more power, processing capability and cooling capacities, which enhances the levels of environmental problems. Thus, the main reasons for the need for Green IT are the change in climatic conditions due to global warming, reliability of power, cost savings and high power consumption. It is the need of the hour to incorporate Green Computing in all aspects of our lives be it personal of business needs. Green computing reduces the energy consumption and eliminates the environmental hazards by optimization and using cloud resources for businesses, expand the productivity, enhance product lifetime and support recycling and biodegradability. The Green IT Migration architecture is given in figure 1.
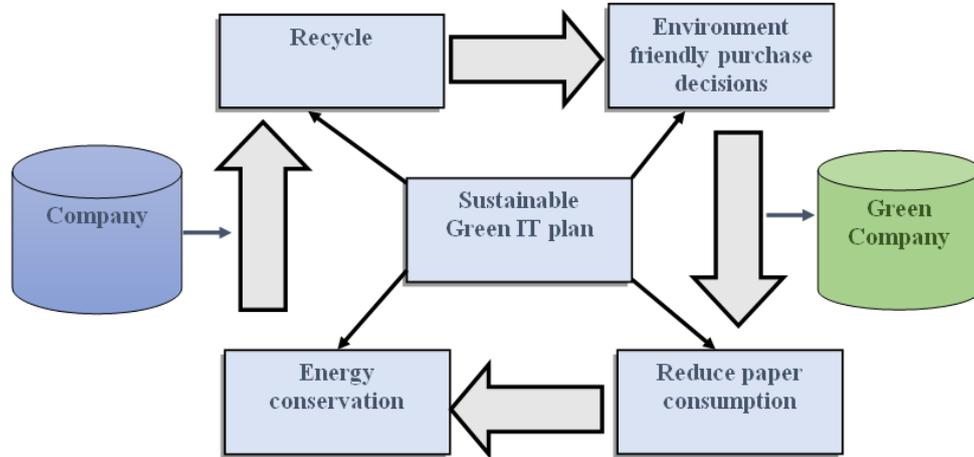

Figure 1: Green IT Migration Architecture

IV. ADVANTAGES OF GREEN COMPUTING

There are multiple benefits of Green Computing that could lead to its widespread adoption. Some of them have been mentioned below:
1) Efficient, effective and dynamic resource utilization.
2) Recycling and reuse of the existing IT assets can lead to a lot of cost savings.
3) Green IT is an environment friendly technology which deals with Green Design, Green Manufacturing, Green Use and Green Disposal as shown in figure 2.
4) Improved social and corporate status for the company because of loyal customers and employees.
5) Meets the environmental policies and regulatory requirements.
6) Effective risk management strategies.

V. GREEN COMPUTING APPROACHES

To resolve the growing environmental issues linked to Computing and IT, a wide range of initiatives have been taken up by the government and private organizations, computer manufacturers and service providers. Many IT organizations are looking for Green IT solutions to achieve the energy efficiency and power management, reducing the costs and recycling of their wastes. Some of the Green IT approaches are mentioned below:
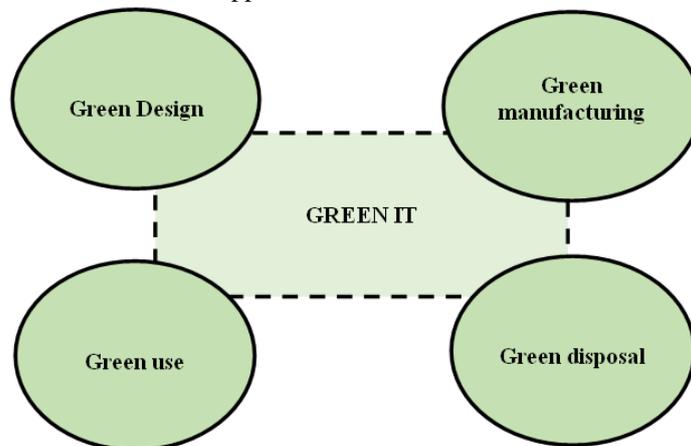

Figure 2: Approaches to Green IT

1) **Extension of product lifetime:** Enhanced product lifetime can save our resources providing energy efficiency and waste reduction for sustainability of the environment. Modern businesses and IT organizations should

update their equipment and add small reusable components which can be easily replaced during the repair operation. Such products are more durable and require less replacements, thereby saving the resources efficiently.

2) **Energy Efficient Devices and Data centres:** Efficient computer should be developed that have the least space and time complexity and require the least power. Green IT provides us with energy saving programs. It focuses on maximizing the energy use and computational efficiency while reducing the energy consumption, utility costs and adverse greenhouse effects. Additionally, power consumption at different IT companies should be minimized by using energy preserving solutions and taking care of lighting of the industry, cooling process for hardware devices. To act as a green machine, the device should have power management features like sleep and hibernate mode that allows the device to be on stand-by mode, while preserving our work as well as saving energy. The Green data centres focus on saving the money, energy, and resources thus significantly improving the vision of the businesses towards a much better environment. Such data centres can adopt several features like monitoring the energy usage, reduction in server costs, optimizing server efficiency, usage of energy efficient hardware, proper cooling and air management system and meeting the regulatory standards.

3) **Optimized software implementation:** Better and augmented software solutions should be deployed to enhance the resource utilization and efficiency. Proper algorithms with low time and space complexity should be taken in consideration. To maximize the use of different resources and complicated tasks, scheduling, resource allocation and scaling methods could be used. The workload should be distributed among different processes, thus reducing the overall energy consumption. Server virtualization is another method of saving the resources and energy. Multiple operating systems can work on a single physical machine, eliminating the need of unnecessary hardware resources.

4) **Terminal servers:** All the users are connected to the central server. All calculations and computational work is done at the server level. This process consumes one-eighth of the total energy consumed by the individual workstation without a central server.

5) **Cloud Computing:** Cloud computing is a reasonable, amenable and extensible technology that has a considerable imprint on the global carbon emission. As per Microsoft [16], enormous businesses can lower their energy use, cost and carbon emissions by up to 30 percent if they migrate towards the cloud. Similarly, smaller businesses can also reduce energy use and carbon emissions by up to 90 percent by using cloud services instead of physical hardware platform. Dynamic resource utilization, Green data center, multi-user environment, enhanced disaster recovery and risk management system are the approaches that enable cloud computing to have lower energy requirements and carbon emissions.

6) **Enhanced data centre cooling techniques:** This may be implemented by moving the data centres near the cooling system by concentrating cold air on the desired place and reduce leakage of energy. Using chilled loop and free cooling techniques, businesses can decrease their energy consumption. The use of innovative, green and renewable sources of energy enables to reduce the dire need for electricity and relieves the already overloaded electric power stations.

7) **Effective storage techniques:** Data storage techniques also play a vital role in power management and energy conservation. For instance, data stored in a hard disk requires less power as compared to some other hardware components of a computer. However, the data that is stored in a flash drive consumes even lesser power than a hard disk.

8) **E-Waste Management:** This deals with the reduction in the emission of harmful substances affecting the environment especially by the extractive industries, preserving the rare materials, easy recovery of the materials, reusing and recycling and donating to the non-profit or charity organizations like NGOs, special schools for underprivileged students and likewise.

9) **Green acquisition and resource management:** This deals with purchasing of the energy efficient and ecofriendly computer hardware equipment that are programmed to extend the equipment lifetime, recycle and indulge with the suppliers who manufacture environment friendly material, have proper packaging and waste management programs.

VI. GREEN COMPUTING BARRIERS

Although Green Computing is a futuristic technology, yet there are some barriers to its adoption. According to a recent survey some of the barriers have been given in figure 3. The companies who want to adopt Green IT should collaborate with the other interested businesses and individuals to remove these barriers and implement Green IT practices at every level and contribute to a better environment.
Few barriers to Green IT adoption are mentioned below:
1) The biggest barrier to the adoption of Green IT is initial capital costs.
2) Difficulties in replacing the existing technology and the reengineering of processes and businesses is the second biggest challenge.
3) Cultural and behavioural reluctance to change is another barrier.
4) Mismanagement of Green computing and associated initiatives.
5) Lack of management drive and support.
6) Lack of understanding by the personnel and reluctance to learn new skills.
7) Lack of green products available.

8) No personnel with enhanced green skillsets.
9) Lack of motivation among the stakeholders.
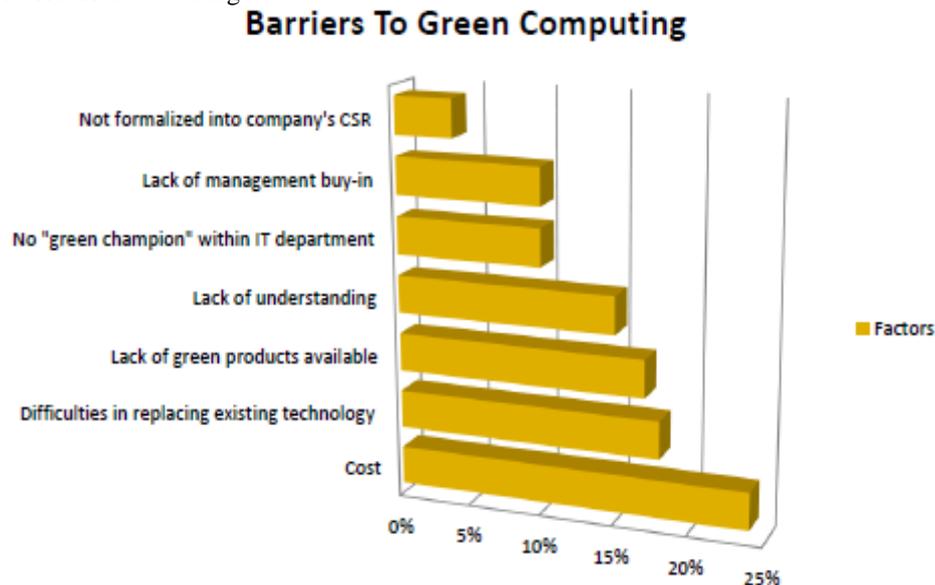10) Fear of joblessness or retraining.

Figure 3: Barriers to Green Computing[17]

VII. GREEN COMPUTING APPLICATIONS

A few recent Green Computing applications in use have been given below [18]:

1) **Blackle:** Blackle is based upon the theory that different colours absorb different quantities of energies. It is a Google powered search engine based on the idea that an empty word page or Google home page will consume a power of 74Watts when the screen is white. But when the screen is black, it consumes only 59Watts of power. Therefore, if everyone started to use Blackle, 750MegaWatts of power can be saved each year.

2) **Zonbu Computer:** This is a very energy efficient computer. It has a Linus OS with a processor of 1.2GHz and 515Mb RAM. Zonbu uses only one-third of the power a regular light bulb requires. It has no movable components, neither a fan. It is very cost effective and has a price of US$99 only. A newly bought device requires a two-year subscription signup.

3) **Fit-PC:** This computer is tiny of the size of a paperback. It operates on Windows XP or Linux OS. It can be used at places where a regular computer seems too heavy, noisy and requiring enormous power. Fit-PC is noiseless and consumes only 5watts power unlike a traditional computer that consumes the same amount in 1 hour.

4) **The Asus Eee PC and other ulta portables:** The word "ultra-portable" refers to a category of PCs that are characterized by small size, very low CPU power, small screen, low cost and flash drives. In comparison to the traditional PC, they work more efficiently and require low power. Asus Eee PC is ultra-portable, has a size of paperback and a weight of less than 1kg.Operating system that can be used is Linux. It supports flash drive as well as wifi.

5) **Sunray thin client:** This is a thin desktop client developed by Sun Microsystems. It consumes very less electricity than a traditional PC. Power consumed by Sunray is 4-8watts. This PC has applications in cost sensitive environments like finance, health, call centres, education and service providers.

VIII. CONCLUSION

Although the proliferation of Information Technology and other businesses has revolutionized our day today lives, but it also poses a severe threat to our environment. Therefore, it is the need of the hour for both government and private sector organizations to collaborate with each other, propose and deploy Green IT solutions that will improve the health of our milieu. Green IT deals with how to design, manufacture use and dispose our green computing resources. This paper provides an overview about the Green technology, its architecture, advantages, approaches, challenges, applications such that the IT industry can achieve savings and provide sustainable business solutions.

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