Green Computing: Current Research Trends

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Abstract: *Green computing in a broader way is the practices and procedures of designing, manufacturing, using of computing resources in an environment friendly way while maintaining overall computing performance and finally disposing in a way that reduces their environmental impact. This means reduction in use of hazardous materials, maximizing output from the product during its lifetime while minimizing energy consumption and also reusability or recyclability and biodegradability of used products and wastes. Many corporate organizations are taking initiatives to reduce the harmful impact of their operations on the environment. United Nations Framework Convention on Climate Change (UNFCC) is an international environment treaty whose objective is to stabilize the emission of green house gases in the atmosphere at a level that would prevent dangerous anthropogenic interference with the eco system. Sustainable development means developing without damaging the requirements of the future generations. That is meeting human development goals while preserving natural resources and ecosystems on which the society depends. This paper is a survey of several important current researches related to the field of green computing which emphasises the importance of green computing for sustainable development.*

Keywords: Sustainable development, Green Computing, Data Centre, Energy efficiency

1. Introduction

In this section a brief discussion is made on various issues related to green computing. This is followed by a section on survey of recent researches in the field of green computing.

Earth and the Environment:
Over the past few decades there has been lot of change across in temperature and weather patterns due to increase in greenhouse gases on account of massive deforestation, burning of fossil fuel and rapid industrialisation. Consequently, the average temperature of the air and the ocean has increased. Due to increase in the air temperature there has been more melting of snow resulting in an increase in sea levels.

Impact of Information Technology upon Environment:
Over the same period of time the rise in the use of computers have increased manifold. The combined effect of the energy needed to run these devices and the electricity required to maintain the cooling infrastructure for these devices have an impact on the environment. This is an area of serious concern and is drawing people for research in the field of Green Computing which is about using computer in an eco friendly way.

Green Information Technology:
Green computing should address environmental sustainability primarily by focusing on design, manufacture, use and disposal of computer and other related devices in an eco friendly way [1]. Green I.T 1.0 is the greening of I.T by laying emphasis on reengineering I.T products and processes to improve the energy efficiency of I.T and minimization of their carbon footprint and their environmental impact. Green I.T 2.0 is the greening by I.T and includes coordinating, reengineering and optimization of the supply chain, manufacturing process and workflow of the organization to reduce the impact on environment [2].

Section I contains the introduction, section II contain the survey of recent literature in the related domain and section III concludes with a brief discussion on the direction of future research and its importance.

2. Survey

The following are the various areas where research in green computing is being carried out: Energy Consumption; E-Waste Recycling; Data Center Consolidation and Optimization; Virtualization; I. T Products and Eco-labeling [3].

Usvuvetal [4] proposed some techniques to make cloud computing more energy efficient. A resource-utilization aware energy saving server consolidation algorithm (RUAEE) is proposed by Han et al. [5] which can be used in providing better utilization of resource while causing reduction in the number of virtual machine live migrations. Experimental results show that is able to reduction in the energy consumption and service-level agreement (SLA) violation in cloud data center can be achieved by RUAEE as per the experimental results.

Sharma [6] presented a study on Green Computing exploring the development of efficient computer programs using all the available cores of a CPU resulting in faster execution as compared to any single-core implementation of the program which further results in energy savings. A case study is also included supporting the study. Besides the study also pointed out that when number of computation is more the multi core approach showed superior performance else the performance is inferior as compared to the single-core computation.

Kumar et al. [7] proposed Huffman coding and Ant Colony Optimization (ACO) based Lifetime Maximization (HA-LM) technique for haphazardly distributed Wireless Sensor Networks (WSNs). They showed the superiority of the proposed method when compared with the state-of-the-art methods. Farooqi et al. [8] have made a comparison of various practices of green cloud computing along with the results of each.

Kharchenko et al. [9] explained notions and classification of green I.T engineering besides analyzing the main principles of development and implementation, indicators and values of green computing and description of European Union project GreenCo. More et al. [10] studied various techniques, models, algorithms, for energy competent green cloud computing. The technique used is virtualization. The study mainly involves consolidation of virtual machines (VMs). Power consumption can be decreased by deactivating and reactivating physical machines as per the existing demand of workload. The approaches discussed are centred around saving power and making data centers energy efficient.

Mesaad et al. [11] provided an analysis of the current green computing initiatives and an overall comparison between them to show their efficiency. HP program is the greenest computing waste-management initiatives from the point of e- waste management. Considering Energy consumption, the Energy Star and EPEAT initiatives happen to be the most successful program based on the latest energy savings statistics and their users trusted labelling.

AlMusbahi et al. [12] discussed about the developments and challenges of green computing. Kern [13] discussed about awareness and approaches of creating awareness on green computing with emphasis on green software along with a user survey. Tyurin et al. [14] proposed both new indexes of calculating competency of computing systems and synthesis technique of fault tolerant delay insensitive circuits along with an analysis of semi modularity for fault – tolerant circuits. Sharma et al. [15] made an analysis and describes a green university data centre and in the process makes an excellent insight into the various operational and competency characteristics.

Shaikh et al. [16] discussed about green Internet of Things by exploring ways of successfull and efficient deployment of various enabling technologies like the Internet, smart object and sensors to name a few. They have also made a review on various IoT applications, projects and standardization efforts going on at present along with identification of few challenges that has to be addressed in the near future to successfully enable a greenIoT.

Pahlevan et al. [17] presented an optimization framework for managing green data centers using multilevel energy reduction techniques jointly. The results obtained demonstrate satisfactory results as there is considerable, up to 96% savings in electricity bill. Taufiq et al. [18] in their study discussed about cloud computing and green I.T to discover the important factors that influences adoption of SaaS cloud computing as a means to adopt green I.T. Theory of planned behaviour (T.P.B) is used and their proposed model successfully explains the concept of cloud computing and green I.Tjointly.

Lin et al. [19] proposed a new green video transmission (GVT) algorithm using video clustering and channel assignment that will help in video transmission. Design is also made of a video clustering model based on the basis of game theory for grouping the different video parts stored in mobile devices. The analysis and simulations demonstrates a superior video transmission performance by the proposed GTV algorithm.

Asad et al. [20] divided the big data enterprise into six planes which they considered vital as having influence on the energy consumption of data centers. A survey is also made by them about the important strategies that will make these six vital planes greener. The challenges and directions in this area are also discussed. Nanath et al. [21] discussed about the impact of Green information systems (Green IS) practices on Green innovations and the various ways in which corporations get advantage over competitors because of better performance of Green innovations.

Sofia et al. [22] proposed a scheduling algorithm called Green Task Scheduling (GTS) Algorithm to lower the use of cloud resources. A decrease in cost of hardware is also an advantage of this algorithm. In order to manage the voltage as well as the frequency of the processor without impairing the performance, a technique called as Dynamic Voltage Frequency Scaling (DVFS) is used. Favourable results are obtained by implementing GTS along with DVFS in cloud computing environment.

[23] have made analysis about various issues related to green computing like the relation between environment and information technology, green information technology advantages, adoption of green computing, eco friendly practices, green computer design, green information technology standards and regulations and about industry associations. [24] et al. in their study emphasised on reducing energy consumption and carbon footprint of various computing devices.

3. Conclusion

In the coming years there is a scope of lot of research work that needs to be done in the field of green computing. Research could be concentrated around making data centers and cloud computing more energy efficient. The corporate organizations must take more green initiatives. All stake holders must work jointly for a greener world. Otherwise, the human race will face severe problems in the coming years. There are as such no limitations of this survey but in future it is expected that there will be lot of research related to green computing. That is the scope of future improvement of this work.

4. Acknowledgement

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