Uses of Green Computing and Energy Consumption

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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

I. INTRODUCTION

The users of IT are growing exponentially per year, it has now become compulsory for IT stake holders to pay attention on the power consumption by IT resources and come up with innovative ideas and methods for reducing the energy consumption by using software approaches, hardware manufacturing and people's green practice and awareness. Latest researches have proved that even a single click of mouse on a web page hitting the server consumes energy and dissipate heat in the environment. Earth is already facing problem of global warming & green gas emission because of development of small, medium and large scale industries all over the world.

After the conclusion of various research of energy consumption by IT resources, new paradigm called "Green Computing" coined. Green Computing can be defined as *"Innovative approach to manufacture eco-friendly hardware devices & components, innovative techniques for developing energy saving software(s) and set of practices to support the critical mission 'Saving Earth'"*.

In the article Harnessing Green IT : Principle and Practices , San Murungesan defines the field of green computing as "the study and practice of designing, manufacturing using and disposing of computers, servers and associated subsystems such as monitors, printers, storage devices and networking and communication systems efficiently effectively with minimal or no impact on the environment.

In today's scenario data volumes are going to double after every 18 months, and every one want to keep their data online. For keeping huge data the hardware infrastructure need improvement in data center which is responsible for the heating and CO2 emission. Table 1 shows the percentage of consumption by various equipment of data centres.

Equipments used in Cloud Data Center	Percentage consumption
Cooling Device (Chiller, Computer Room Air Conditioning (CRAC))	42%
IT Equipment	30%
Electrical Equipments (UPS, Power Distribution Units (PDUs), lighting)	28%

Table 1. Shows Percent of Power Consumption by DataCenterDevice[8].

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1.1 Environment Regulations

Looking for high impact of green computing to save the life on the earth, government& corporate sectors also impose regulations and acts. European standards specially focused and imposed to control hazardous material used in manufacture.

- **WEEE - (Waste Electrical and Electronic Equipment (WEEE) Regulations 2013) in UK**- It imposes responsibility on equipment manufactures to take back the e-waste equipment free of cost.
- **ROHS - (Restriction of Hazardous Substances)**- It restricted on usage of six hazardous materials like lead, mercury, cadmium, hexavalent chromium, poly brominated biphenyls and polybrominated diphenyl ethers. It was adopted in February 2003 by the European Union.
- **EPEAT - (Electronic Product Environmental Assessment Tool)**- Tools created to check the efficiency of desktop monitors and notebook on 23 required and 34 optional environmental criteria.It is supervised by the Green Electronics Council, which itself a programme of the International Sustainability Development Foundation (ISDF).
- **Energy star**- Energy performance is regulated by standard developed for external and internal power supplies, idle, sleep and stand by modes.It is a U.S. Environmental Protection Agency (EPA) voluntary program that assist to save money and environment through superior energy efficiency.

1.2 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.

Sharma [1] 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 thestudy 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. [2] 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.

Sofia et al. [3] proposed a scheduling algorithm called GreenTaskScheduling(GTS)Algorithmtolowerthe 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. Favorable results are obtained by implementing GTS along with DVFS in cloud computing environment.

Shaikh et al. [4] discussed about green Internet of Things by exploring ways of successful 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.T jointly.

1.3 Problem Statement

The problem at hand is the negative impact of traditional technologies on the environment. Conventional energy sources, inefficient practices, and unsustainable consumption patterns contribute to greenhouse gas emissions, pollution, and ecological damage.

This calls for innovative solutions that can minimize the environmental footprint and address these pressing issues.

1.4 Objectives

The objective of green technology is to foster a positive impact on the environment. It aims to develop and implement sustainable solutions that reduce pollution, conserve resources, mitigate climate change, and promote ecological balance. By adopting green technology, we strive for a greener, more sustainable future that prioritizes environmental preservation and addresses the challenges we face today.

The impact of green technology on the environment is far-reaching, encompassing various sectors and addressing multiple environmental issues. Through the adoption of sustainable practices, renewable energy, and eco-friendly technologies, green technology plays a vital role in minimizing environmental damage and creating a more sustainable and resilient planet.

II. WHY GREEN COMPUTING?

Green Computing is motivating us to rethink on current trends of hardware, software and people who are obstacle in the way of the mission 'Saving Earth'. This can be achieved by manufacturing of eco friendly hardware, design & development of power saving optimized software & information system for energy saving, eco friendly process & practices adapted by IT stack holders. There is need of techniques & methods to design and manufacture environmental friendly devices, optimization of coding in such a way to reduce energy consumption & reduce heat dissipation, education to create best IT practitioner supporting mission 'Green Earth' and enforcement of National and International Standards for Green IT.

To endorse green computing at all feasible levels, the following approaches came into existence.

- **Green use:** Use computer and peripheral devices in an eco-friendly mode.
- **Green disposal**: Recycling or disposal of e-waste in proper manner.
- **Green design**: Try to design equipment with low emission power and heating.
- **Green manufacturing**: Try to use more easily disposal elements at the time of manufacturing.
- **Material recycling**: Parts from outdated systems can be recycled to make its green.
- **Telecommunication**-
  Teleconferencing and telepresence technologies are also innovative methods used for discussing and data transfer, which is also a green computing initiatives.

There are various important reasons to adopt green computing -

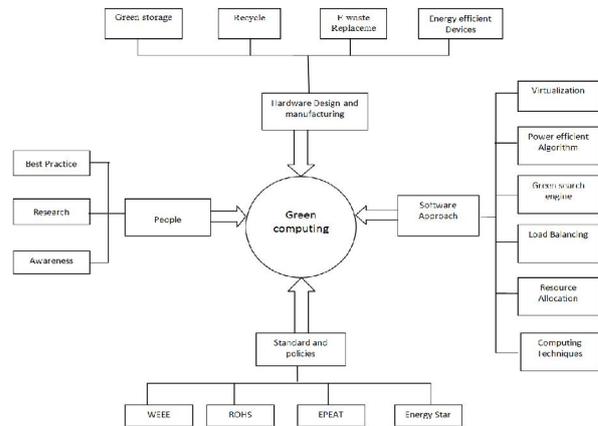It promotes usage of disposable products.

Adopting green can also reduce cost and therefore, beneficiary for an enterprise.

It also reduces risk of using chemical which may cause danger for the human being.

It also reduces noise pollution

Energy conservation save energy for future use.

2.1 Holistic Approach of Green Computing

III. HARDWARE DESIGN & SOFTWARE TECHNIQUES

There are two approaches which are obliging to make computing green.

3.1 Hardware Design

Computer and peripherals emit significant amount of energy in sleep and standby modes. A single PC release more heat than a 100-watt light bulb. With careless use of electrical devices, we are also contributing for CO_2 emission. Manufactures do not provide proper power off in many devices like DVD players, DVD recorder, printer etc.

- **Fit PC**– Fit PC can draw only 5 watts which is less as compared to normal PC which consumes 5 watts in 1 hour only. This device support windows and linux operating system.
- **Zonbu Computers**- This computer consumes only one third powers as consumed by a light bulb. It also supportlinux operating system.
- **Sunray Thin Client**- Sunray thin client are designed to consume less electricity than frequently used desktops. It only consumes 4 to 8 watts of power, it cannot do heavy computation,

because that types of computation can be done by server.

3.2 Software Techniques

Green computing has become compulsory for various embedded devices and large data centres. There is need of energy efficient software that allows the programmer to write the energy efficient code.. Special compilers which will generate the code for optimisation of loops and functions according to the requirement of the system under quality of services.

- **Operating System Support-**Some programs support operating system that allows users to adjust manually supplies in CPU to reduce electricity consumptions. Sometimes this is also automatically handled by the operating system.
- **Virtualization-**Virtualization, allow a system administrator to combine several virtual machines on one single, powerful physical system, by this means we can reduce power and cooling consumption. Several commercial companies and open-source software packages are available to enable virtual machine.
- **Dynamic Voltage Frequency Scaling Technique (DVFS):-** Supply voltage can be regulated with the help of operating clock given in the electronic equipment. But this method cannot save more power as compared to other.

3.3 Green Servers & Big Data Centres.

Because of increasing data, day by day exponentially, it has become compulsory to develop data centres to serve people required information on demand without delay. Green data centres term coined in the modern IT to support green computing. These centres are developed in such a way that minimizes the CO_2 emissions, reduces heat dissipation, energy efficient and uses environmental friendly devices and components. Data centres include many computing devices connecting through network cables which produces heat and hence cooling is required in these data centres to reduce heating impact on computing devices.

Devices being used in data centres must be measured for energy consumption and intelligent provisioning of distribution of energy to such component as per their requirement must be maintained. Components like CPU, switches, ports, RAID (redundant array of inexpensive disks) etc should be observed and effectiveness parameters like power usages, carbon usages, energy usages etc must

be observed. Power management and intelligent power supply should be helpful to solve the problem of energy consumption during sleeping mode. CPU frequency can also be dynamically set as per requirement of computing instructions. Sending hardware components like CPU, switches etc to zero power mode also reduce unnecessary power consumption during sleeping mode. Inside switches particular part can be powered off using usage metrics.

Several energy metrics have been proposed to improve the efficiency of data centre.

1. **PUE (Power Usage Effectiveness)**- It is a metric which conclude the data centre energy efficiency.

PUE=Total facility power/IT equipment Power.

2. **Data Centre infrastructure efficiency (DCIE)**- It is reverse of PUE and represented in % form.

3. **Data centre performance efficiency (DCPE)**- It is a metric calculated as:

DCPE=Useful work/Total facility power

4. **Carbon Usage Effectiveness(CUE)**= It is a metric calculated as:

CUE=Total CO2 emissions from DC energy/Total IT energy

IV. IMPACTS OF GREEN COMPUTING

- It will reduce the overall cost for total consumption of energy and enhance revenue in long term.
- It will save the sufficient energy cost of cloud data centres.
- It will minimize the impact of carbon dioxide emissions.
- It will also reduce the greenhouse effect because of much energy consumption by modern IT systems.
- It will help people to develop eco-friendly electronic devices and components.
- It will provide balanced combination of technology and ecology.
- It will help us to reduce pollution on the earth.
- It will promote more recyclable products.
- It will enforce people to follow Earth Saving Policy.
- It will also reduce risks of using life challenging materials being used in IT.

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V. GREEN AWARENESS WITH ISSUES & CHALLENGES

- Use energy star rated devices although it may be costly initially but profitable in long term.
- Always keep PCs, Laptops or other personal electronic gadgets in sleep mode when not in use.
- It is better to turn personal e-gadgets switched off when not in use.
- Recycle old electronic devices but not resell them.
- Always observe the power matrix of IT system being used.
- Use power sensor smart devices to reduce the power consumption.
- Research cost is high.
- Eco friendly devices are costly at present.
- Less awareness among people about ecological issues of the Life on the Earth.
- Replace of existing technology with eco friendly technology is increasing expenditure.
- Low speed production of green devices because of fast technological changes on techniques.
- Green computing is more public issue than private issue.

VI. CONCLUSION

Extensive heat consumption is responsible and one of the reason for global warming which is a challenge for all the researchers. Goal of green computing is to minimize the carbon emission. Recycling of various computing equipment can also minimize harmful material from the environment.

Green computing is an innovative approach to save environment and mankind from various environmental hazards. Government & corporate also came in focus to make rules and regulations regarding e-waste, energy consumption, re-use of disposable material. As cloud computing is having its benefits; apart from this, up to certain extent, it is also responsible for CO_2 emission. So we can use any hardware or software approach to make computing green.

Eco-friendly environment are created by manufacturer by designing green devices. Energy efficient hardware's are available to ensure minimum energy consumption. Search engine like Blackle also available which claim and ensure to minimize energy consumption.

Green computing thus has deep impact on society and environment to make the earth green for survival with technology enhancement

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