Green IT-An Eco-friendly Practices and Methods for Environmental Sustainability

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Abstract: Information Technology is like the central nervous system for business, private sectors, Government organizations and for the social infrastructure. Of course it connects all part of the world. Most of the works are computerized and automated solely depends only on IT. IT sector depends on the electricity to run all the works and at the same time high power consumption emits larger heat by the resources which are threatening and giving unsustainable climatic conditions on the globe. So there is a need to follow the best practices for Energy conservation as well as gradual awareness for bringing environmental sustainability. The best environmental practices can reduce the use of hazardous materials and maximize Energy efficiency during product’s lifetime to avoid Green House Gas Emissions and Co2. Green IT plays a vital role to improve the climate conditions on earth by “Go Green approaches” by effective design, manufacture, use and disposal of e-wastes with no or very minimal cause on the environment. Using Green IT stakeholders or organization can avoid toxic landfills by reduce and reuse equipment’s with the manufacturing of biodegradable components. Through Green IT cost savings is possible with energy efficient products through the best practices, approaches, standards and techniques like virtualization and configuring the servers by power management options and there by gaining energy from renewable natural resources, also switching to digitalization to roll out traditional paper works. In this research paper, the proposed approach is to address the power consumption and environmental issues from various ITC resources like compute, network and storage with better algorithms like ACVFS and Energy-Conscience Workload Scheduling, Resource Efficiency techniques in data centers, thin provisioning and by recycling approaches like 3R’s for managing e-wastes to make the Earth Greener for the next generation.

Keywords: Green Information Technology, Voltage Frequency Scaling, Power Consumption,

I. INTRODUCTION

Adopting new approaches to greening the IT is our foremost responsibility towards making the sustainable Environment. The large Enterprises and other organizations should adopt sound practices for green environment. Over the several years IT has contributed a lot to make rich our lives through automation and offering convenience with huge benefits. Adoption of IT provided many advances and at the same time it is creating environmental problems, which most of people don’t realize. Computers and other resources consume significant amount of power leads to greenhouse gas emissions. Moreover IT Hardware Resources tends to more environmental impact during production and disposal [1]. To reduce the Environmental problems and to create sustainable environment every computer user should Green their IT systems and also the way to use it. Green IT makes the environment sustainable by enhancing the energy efficiency, minimizing greenhouse gases and encouraging reusability and recycling the products. In this article we address the issues arising from IT and from its products, services, operations and applications and in addition to that this paper proposed Green IT strategies for establishments and outline specific ways to reduce environmental impact.

II. BACKGROUND STUDY

2.1 E-waste

Due to rapid technological development some Electronic products has become obsolete, discarded and attaining the end of useful life. Some example of e-wastages are TV, Computer monitors, CD Players and Printers.

2.2 Green IT and promoting sustainable balance

Green IT refers to efficient utilization of computing resources, accessories which may not affect the environment and contribute minimum to environmental degradation. These devices, accessories emit gaseous emissions, chemicals when not in use. To protect the natural environment and socio-environment Global Policy Regulations (GPR) should be followed. Even though most of the products Now-a-days are Eco friendly until to the maximum, Information and communication Technologies (ICT) to guarantee a Friendly Eco-system thereby avoiding Green Houses Gases, Carbon Foot Prints and non-biodegradable substances which can deface the soil. Hence Green IT awareness to be intensified to ensure the environment is not destructive. For sustainable development IT organizations through Corporate Social responsibility (CSR) could raise Green Computing awareness among Computer Users. These kinds of campaigns will definitely help to attain acceptable environmental behaviors that vigil the natural and socio environments for promoting Eco Balanced Environment.

2.3 Environmental Issues

The accumulation of Greenhouse gases is changing the climate patterns with drought and floods in some regions and posing to global temperature at higher rate causing serious problems on earth. To stop the accumulation of GHG in the atmosphere we should stop burning coal or oil to generate electricity which releases Co2 will cause health hazards, acid rain.
Reducing electric power consumption and usage of renewable energy resources may bring considerable less impact on the environment. Let us see the strategies and technologies to provide high environmental benefit.

2.4 Green renewable Energy

Green Energy is Green electricity that is produced with little-no-environmental impact and does not mix GHG in air that does not contribute to global warming and it can be done in following methods:

1. **Varied**: Green Energy sources generated by the movement of air and water such as wind, hydro and solar energy.
2. **Renewable**: They are the resources that depend on fuel resources that exist for short period of time and it do not disappear. Such fuels include sun, wind, and biomass.
3. **Conventional power**: This includes the burning of fossil fuels such as coal, natural gas and oil. Nuclear power emits no GHG during power generation but long-term radioactive storage will be there.

Fig.1. Different Types of Energy Resources [3].

2.5 Reasons with Benefits to make use of Green IT

Green IT strives hard to achieve cost with operation efficiency to abide social and ethical responsibilities. Green IT wide spread with numerous focus areas and activities includes

1. Energy efficient computing;
2. Data center design efficiency;
3. Virtualization
4. Safe disposal and recycling
5. Green assessment tools and methodologies
7. Green Metrics.

III. THE HOLISTIC APPROACH TO GREEN IT

We can address environmental impact problems with six holistic approaches and directions [1]

- **Green design**: Design energy efficient and eco-friendly computers, peripherals and chillers.
- **Green Manufacturing**: Manufacturing components of computer and other sub products with minimal or no impact on the environment.
- **Green use**: Reduce the energy consumption of computer and other equipment’s in an environmental friendly manner.
- **Green Disposal**: Refurbish and reuse of old computers and other electronic items properly and recycle or dispose them in safe way.

IV. ACHIEVING GREEN IT BY THE FOLLOWING TECHNIQUES AND TECHNOLOGIES:

4.1 Green data centers:

Data centers are at the heart of the IT-driven economy. Power consumption of a single data centre can range from tens to a hundred megawatts, and operational costs can run into great extensive expense in a month. Data centre operators incorporate careful design and optimizations to reduce large-scale data centers energy consumption. Because data centre design and operations are a source of competitive advantage, insight into modern data centers is scarce [4]. To reduce the power consumption we can go for virtualization techniques which help us to reduce the floors infrastructure as well as cost savings.

4.1.1 Virtualization in data centers

Virtualization is the hardware level of abstraction. Virtual machines can be isolated from physical system failures to increase system availability and provisioning. Virtual machines provide much more granular control over workloads. Virtual machines can be moved to additional servers as demand increases, while unused or lightly-used servers can be managed to minimize power usage. Overall, virtualization can increase server CPU usage by 30-60%. As the CPU usage is increased, the energy efficiency of the server power supply will also increase. Virtualization and consolidation will have the effect of decreasing the total number of servers or, at the least, deferring the purchase of new servers which ultimately saves power and cost [4]. To calculate the Power Usage Efficiency (PUE) of the data centre we can use the below formula:

- **Power saving options**.
- **Green Metrics**.

There were two primary metrics introduced to calculate PUE, 1. PUE=Total Power into Datacenter/IT equipment power.
2. DciE=IT equipment Power/Total Power into Datacenter.
Look at an example to see how PUE is calculated. If the power entering the data center (measured at the Kill-a-watt meter) is 100 kW and the power consumed by the IT load (measured at the output of the UPS) is 30 kW, we would calculate PUE as follows:

\[ \text{PUE} = \frac{100}{30} = 3.0. \]

Suppose we now decide to virtualize a number of servers. In fact, we are so successful with virtualization that we are able to reduce the power to IT equipment by 25 kW and the overall power to our data center by the same amount. What will happen to our PUE? [4].

\[ \text{PUE after Virtualization} = \frac{75}{15} = 5.0 \]

When the IT load is reduced, Infrastructure Load/IT load will always increase, resulting in an increase in the PUE. Inversely, increasing the IT load will always decrease the PUE [4]. When we track the PUE it is very important to track IT Load and Infrastructure changes so that we will come to know why PUE has changed.

4.1.2 Green Virtualization:

(a) Virtual storage:

This is different from server virtualization and here Direct Attached Storage (DAS) and Storage Area Network (SAN) are grouped so that it will look to applications as all storage is in single disk. It considered as main part for server virtualization strategy because it works parallel with physical servers as it makes with virtual servers.

(b) Desktop Virtualization:

Clients can take the advantage from remotely accessing their applications, resources. It’s a less power consumption dumb terminal or Zero Client. Virtualization replaces the traditional Fat Client to thin.

(c) Application Infrastructure Virtualization:

Considerable Energy savings can be achieved by virtualizing the application infrastructure because it is disaggregated from physical infrastructure which they execute. In the Virtualized application infrastructure the workloads can be dynamically allocated or migrate across the pool of server resources for business agility [6].

(d) Containerization:

Containers are the software level of abstraction. It is light weight and alternative to full machine virtualization. It will load the application into the virtual machine without the dependencies. Docker containers are designed to run from physical machines to virtual machines, bare metals etc. Containers are used to deploy the application very fast to attain cost and operation efficiency. It has less overhead on comparing virtualization because of the involvement of hypervisor.

4.1.3 Green data Management:

Although we consume more storage for several purposes that adds more drives to handle the data piling. This may lead to increase the cost of cooling the storage systems. Tiered Storage Model for Green Data management

Tier 1- For Sensitive Data: Tier 1 data are most critical data and it’s very expensive to store. To make it Green instead of storing in your laptop store it in data centers that are using renewable energy.

Tier 2- High valued data but not sensitive: Data can be accessed rarely and therefore its very less cost to purchase. Tier 2 data would be some files or documents stored on collaboration host. Here at some point of time data duplication may occur in Tier-2 so we can see to that the data should store once and this can be ensured with the technique of de-duplication.

Tier 3- Transitional type storage: Here the data is valuable but can be accessed less frequently and sometimes called as persistent storage. To save energy MAID (Massive Arrays Of Idle Disk) is used to keep the drives powered on until the data is needed.

Tier 4- archive: This is tape based libraries to retain the data for long time and this type of storage is more efficient in its energy because it’s mostly offline.

4.1.4 Thin Provisioning:

Before a decade the only supported storage provisioning method was Thick Provisioning. Now the new technology called Thin Provisioning reserves capacity dynamically and it is a method to optimize efficiency with which available space is utilized in SAN (Storage Area Network).

4.2 Greener Hosted Data Centre Services

There are some choices to maintain the data by making physical infrastructure to maintain by staffing or by means of tiered storage model or by hosted data center provider because its greener by means of consolidating the operations to gain agility and thereby reducing the amount of power and equipment. They can run all the systems in-house [6].

4.2.1 Physical Power plant

Data Centers not only occupies much space rather it needs more power and cooling. So most of the cities restrict the power providing to data centers and new data centers are moving towards less demand for resource for cleaner electricity and cooling [6].

V. ENHANCING DATA CENTRE EFFICIENCY

Designing the data centre for high efficiency is a crucial problem and it requires the input from several disciplines normally not belongs to IT. While designing the infrastructure Green concerns should be at the top of the list. We can maximize the data centre efficiency by these following ways.

5.1. Choosing the Right Location

Most of the new data centers are moving to the remote locations. The Optic Fibre lines have reduced the cost of keeping the data centers at remote location with less labor and power costs.
5.2 Free Cooling
Cold outside air can be consumed by the cooling equipment when its available is one of the ways to cut the power consumption. The ideal place to design the data centre which has cool, dry climate with sufficient supplies of water. Even though is hard to locate such place but most data centre can be benefited from free cooling for most of the months in a year.

5.3 Water power
Some of the data centers have water purification plant to filter and treat the water more suitable to use in its cooling towers. The other idea is using river water for cooling and we should be careful that it should not affect the aquatic life by water heat level and the permission should also be required at one or more levels.

5.4 District Cooling
This method is efficient and innovative and the local commercial firms maintain large chilling plants and sell cold water to nearby data centers.

VI. GO GREEN WITH BLADE SERVER
In a Blade Server processor package, memory and hard drives are on a single card. In Blade servers this card inserts into a “Rear Plane” with number of connectors for multi-processor cards known as Blades. Blade servers offer more opportunity for achieving Green Efficiency because the power and cooling provided by single server case [6]. Blade server common services are:

(a) Common Power supply:
Blades share a common power supply rather provide individual power for each processor which needs 120-230 volt AC power.

(b) Common Cooling System:
The blade system chassis provides cooling for all blades with better air flow and effectiveness.

(c) A Common Network Interface:
The Blade case provides a Common network backplane with port for individual blade server and this is same to the concept of router which connects a series of network interface on single LAN to external LAN.

Go Green with Online Communication systems:
Reduce paper purchase and increase the organization productivity with less cost by using back to back paper printing which helps to reduce the toner requirements also. The gradual usage of online communication system without using the paper will help us to reduce carbon footprints and consumption of forests [7].

6.1 Reducing the Travel purpose of Staff, suppliers and clients:
For most of the organizations the mode of travel required can be challenged for staff, suppliers and clients [7]. For the need of enhanced infrastructure in the recent years we have seen a great upturn in travel requirements for employees which increases the carbon emissions and to reduce this cause they use the remote conferences, remote working technologies or video conferencing. The adoption of instant messaging software can allow us better for remote conversations. These technologies will help to reduce better less cost of travelling, time saving and preserve the earth from the pollution.

6.2 Terminal Servers in organization:
When using Terminal servers, end users connect to the central server and all of the computations have been done at the server level but end user experiences the operating systems. On comparing the fat clients the terminal servers connected to thin clients in an organization will use 1/5 the amount of power of a normal workstation, results in the reduction of energy cost and consumption. Now-a-days virtual labs have been created using terminal servers connecting with thin clients.

6.3 Energy Efficient In-house Green data centre:
Energy efficiency is the main factor which should be considered in data centre planning and building the phases [8]. Some of the possible guidelines are given.
a. Select the right energy supplier and Infrastructure.
b. Lowering the cooling cost by using natural air.
c. Use existing structure rather than rebuild.
d. Plan the space intelligently.

6.4 Dynamic provisioning of resources:
Match the demand accurately and use the computing resources to shirk resource wastage. Even predicting the demand is more difficult because of dynamic workload. To achieve Energy efficiency and sustainability we should allocate right level of resources by means of elastic resource provisioning to the users with machine learning techniques and it should not be over provisioning or under provisioning at any cost for best SLA and QOS. Efficient provisioning may occur on the client side as well, to consume only what they need based on pay-as-you-go way.

6.5 Thin Client:
Thin client devices are simple computers designed to run applications from the central server or from the data centre. For example both the fat client i.e. Normal Personal Computer and thin clients display the same commonly used windows desktop interface to the end-user with same keyboard and mouse.
The major difference in thin client has the lower microprocessor requirements and lower requirements and compact in size which requires less place to keep the machine and the main advantage of thin client is less power usage on comparing the fat client and also since most of the works processed in data centers no need for necessary software upgrades or hardware upgrades in client side which saves the cost and the user can feel hassle free.

For example if the single fat client consumes 92 watts whereas thin client can consume only 20 watts which saves power to a great extent also with reducing co2. We should note that fat clients have locally installed operating system.
Picking: This process performs manually to sort components that should not be crushed especially batteries, CRT tubes may emit toxic gas substances which is harmful to the environment. 

Disassembly: After the sorting of all components by hands, the second step is to separate and categorize all the parts for recycling processes and to reuse some components.

Size-reduction process: The recycling plant makes the components as more small chunks that it should less than 2 inches in diameter. This method should extract all the dust particles that are eco-friendly.

Over-band magnet: This method should remove all the magnets from the steel or iron components from the refined materials.

Optical identification: After the separation of magnetic materials at this step non-metallic components such as glass or plastic may contain aluminum, brass, copper at their edges and it should be separated.

Water separation: At this last step plastic is separated from glass by make use of water. After separation of all the components they are resold as raw materials for the manufacturing process [13].

VIII. CONCLUSIONS

By simply improving the efficiency of ICT equipment’s with algorithms only cannot be claimed to be Green. It is important to follow the techniques, proper analysis before implementing new technologies, utilizing natural resources in a right sense and keep safety factors rigorously can give us raise in protecting our environment and make as Harnessing Green IT. This paper highlights that further research is required in future to analyze the impact of energy optimization techniques on system performance parameters such as throughput and response time. The responsibility also goes to the provider as well as the customers to make sure that emerging ideas and technologies should not bring irreversible changes which should not threat the health of human society.

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