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# GREEN COMPUTING FOR E-WASTE MANAGEMENT

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**Abstract- With the rapid pace changes in technology and hence the world there is a humongous amount of data generation and data storage and hence energy consumption taking place which has led to the evolution of going green with computing and so with IT – hence the term Green IT or Green Computing is growing essential. Green computing is about using computing and/or IT more efficiently to achieve minimization in energy consumption, and therefore, considering the acquisition of energy efficient IT solutions. Green IT also known as Green Computing is basically the study and practice of designing, manufacturing, using, and disposing of computers, computer related hardware, electronics waste, servers, and associated subsystems. The goal of green computing is to reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime, minimizing the usage of minerals and other natural products required during manufacturing of hardware and promote the recyclability or biodegradability of defunct products and factory waste. Research to accomplish these goals is being continued by working hard into key areas such as making the use of computers as energy efficient as possible, and designing algorithms and systems for efficiency related computer technologies. This paper presents the concept of green computing along with the implementation of the technology.**
**Keywords – green computing, green IT, e-waste**

## 1. INTRODUCTION

With rapid growth of computer and electronics industry and the corresponding e-waste generated, it is essential to properly recycle this waste. E-waste is growing approximately about 4 times faster than any other stream waste generation. According to survey in 2010, 35 to 40 million tons of e-waste was generated and unfortunately only 15% of total waste was recycled properly.

A digital solution to this e-waste problem is Green IT. Green IT also referred to as Green Computing is basically a study and practice of designing, manufacturing, using, and disposing of computers, computer related hardware, electronics waste, servers, and associated subsystems.

The main objective of Green Computing includes the minimization of energy consumption. Another objective includes minimizing the usage of harmful materials in manufacturing of computers, computer related hardware, electronics products, servers, etc. and using as many biodegradable materials as possible.

Also extending the life of any computer hardware or electronics product and minimizing the equipment disposal requirements is one of the objectives.

Reduction in usage of paper and other consumables used is also one of the objectives of green computing. [1]

## 2. APPROACHES TO GREEN IT

There are different approaches to implement green computing and gain the objectives of the same. Following mentioned are the various approaches to green computing. [2]

### *2.1 Virtualization*

Virtualization is process and technology based on cloud infrastructure which allows running two or more logical computer systems onto a single hardware infrastructure. This reduces the power consumption as well as the resource consumption and also the cooling requirements by the hardware. Benefits of maintaining a cloud and implementing virtualization include the following:

Resource Virtualization: With reduction in physical hardware infrastructure, there is also reduction in total physical hardware

### *2.2 footprint.*

Pay-per-use self-service: This service provided by cloud encourages users to use only how much they need and reallocate the resources and infrastructure after they have finished using them.

Multi-tenancy: With this many organizations (public or private) can benefit themselves from a common cloud infrastructure.

### *2.3 Power Management*

According to survey in 2005, 152 billion kWh energy was used by the data centers. ACPI (Advanced Configuration and Power Interface) allows operating system to directly control the power saving aspect of the underlying hardware. According

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to survey, 66% of enterprises focus on the desktop usage rather than laptop usage. Enterprises should shift over to laptop usage as the laptops are more viable from green computing perspective.
Laptops are designed to be energy- efficient in terms of their battery-powered design. The perspectives are adding higher capacity battery to laptop and designing the hardware for laptop that would consume less energy.
Laptops have smaller PSU's (Power Supply Units). Hence the desktop computers have a potential to draw 400Wh energy at full load with a larger PSU, while that for a laptop has potential to draw 90Wh due to smaller PSU.

*2.4 Displays*
Laptops on average consume 20-50 watts of energy while that for desktops the count is 60-200 watts. The CRT's (Cathode Ray Tubes) consume more power than the LCD's (Liquid Crystal Displays) and LED's (Light Emitting Diodes).

*2.5 Material Recycling*
To make one desktop computer it takes at least 240 kilograms of fossil fuels, 22 kilograms of chemicals, and over 1500 kilograms of water. If all computers worked from home one day a week, 5.85 billon gallons of oil would be saved per year. Hence using the outdated systems and parts of the system by recycling is essential.

## 3. PATHWAYS TO GREEN IT

There are different pathways that can be followed to achieve green computing goals and hence minimize the E-waste generation. Following mentioned are the pathways to green computing. [3]

*3.1 Green Design*
Data centers are essential base for any business to begin with. Also these data centers are the huge energy consumers, rated for energy consumption between 1.1% to 1.5% of world's total energy in 2010.
The ICT (Information and Communications Technology) sector roughly emits 2% of global greenhouse gases, of which 15% portion is by data centers, and 5% portion is by large internet data centers. That is, data centers contribute 0.3% emissions of global greenhouse gases and 0.1% by large internet data centers.
Green Design includes designing of energy-efficient data centers. Also algorithm efficiency, resource allocation, and virtualization include in green design issues.

*3.2 Green Manufacturing*
Manufacturing of computers involves usage of toxic materials like bromine and chlorine, lead, mercury, etc. which are hazardous to environment as well as human beings. Hence it is essential that the manufacturers take steps to eliminate or minimize usage of such harmful materials and go for the alternatives. To reduce the waste generation different techniques are used by the manufacturers like using the recycled resources to create new products (for example, recycled plastic), using of renewable energy, monitoring, controlling and managing electricity consumption, recycling waste to create new material for production and waste water recycling using treatment plants. [5]

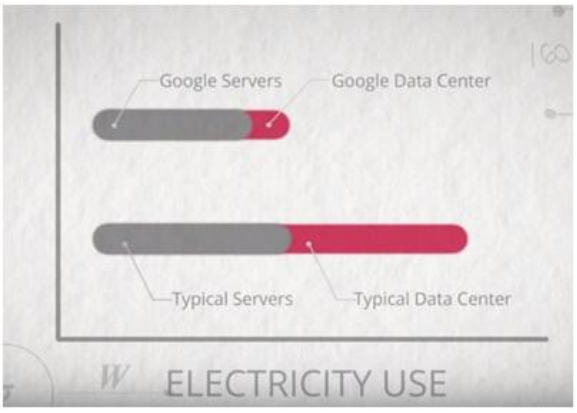
*3.3 Green Disposal*
E-waste is so dreadful that no disposal method can completely eliminate its effects. With rapid growth in generation of e-waste the companies to dispose of this e-waste are also developing.
There are various techniques used by companies to dispose of the e-waste. The first solution is recycling. There should be strict rules to dispose the e-waste. The developed countries should not dump their e-waste into the developing countries. If the developed countries cannot dispose the e-waste in a proper manner they should hand it over to the companies that would recycle this e-waste properly and manufacture new products. The second solution is donation. If we are not using any of our electronics gadgets for a long period of time then we can donate them to some charity trusts so that it can be used by the students for educational purpose. The third solution is taking it back programs. Many manufacturers are available that purchase the old electronics gadgets and evaluate the product and recycle them to create new products. The fourth solution is re-use. Any electronics product should be utilized to its fullest. For example, sound systems and video players can be used for multiple purposes and hence we can increase the utilization of the gadget. The fifth solution is looking for disposal programs. To dispose of the e-waste we can contact private waste management authority of city which would help in disposing of the e-waste in more environment friendly manner. [6]

*3.4 Green Use*
Using the Green manufactured products and reducing the energy consumption and other information storage on system and using them in environment friendly manner is the goal of green use pathway.

## 4. CASE STUDY FOR GOOGLE'S DATA CENTER

Data centers are essential base for any business to begin with. Also these data centers are the huge energy consumers, rated for energy consumption between 1.1% to 1.5% of world's total energy in 2010. [8]

The ICT (Information and Communications Technology) sector roughly emits 2% of global greenhouse gases, of which 15% portion is by data centers, and 5% portion is by large internet data centers. That is, data centers contribute 0.3% emissions of global greenhouse gases and 0.1% by large internet data centers. Green Design includes designing of energy-efficient data centers.
Google data centers are the most efficient data centers in the world. They maintain their data centers by applying some simple techniques.

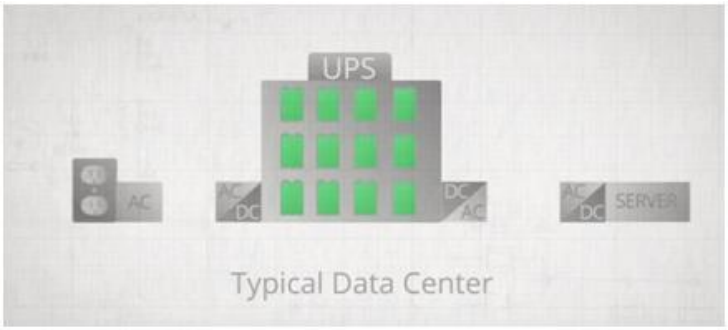


Comparison of energy usage by typical servers and Google servers

Whatever we cannot measure, we cannot manage. Hence, firstly they measure PUE (Power Usage Effectiveness) for their data centers and they don't apply this to only newer equipments but apply it to all their data centers across the world. They gave their first reading in 2008.
PUE is used in industry to measure and help reduce energy used for non computing activities like cooling and power distribution. PUE value is calculated as follows:

$$PUE = \frac{Total\ facility\ energy}{IT\ equipment\ energy}$$

A PUE value of 2.0 means, for every watt of power consumed for an operation to be performed, an additional watt is consumed for cooling purpose and distribution of power to IT equipments. While a PUE value of 1.0 or closer to 1.0 means, almost all the energy is consumed only for the computing purpose.
Since 2008, Google has dropped PUE value significantly. According to Uptime Institute's 2014 data centre survey, PUE value for other data centers is around 1.7. While Google reports a comprehensive TTM (Trailing Twelve Month) PUE of 1.12 across all their data centers, in all seasons and including all the sources of overhead.
For effective working of PUE, Google incorporates PUE into the Building Management System unit and also it calculates this value often; at least once per second.
The values and data vary for different data centers of Google vary due to different power and cooling infrastructures, location of data centers in different climatic conditions. PUE values also get affected by the different seasonal weather patterns.
Google collects all the data essential to calculate the PUE by fitting in multiple on-line power meters in data centers and tracking power consumption and cooling infrastructure for each IT equipment including the servers, storage, and networking equipment.
The second technique used by Google to maintain energy efficient data centers is managing airflow. This is a simple step, where they make sure that they minimize the mixing of hot air and cold air by designing the containments. Google uses Thermal modeling to locate "hot spots" and understand airflow in data centers and blanking plates are used for any empty slots in rack to eliminate hot spots.
To cut the costs and save energy, Google prevents the mixing of hot air behind the server racks and the cold air in front of server racks. This is achieved by hanging plastic curtains to seal off the cold aisle.
The third step used by Google is they use free cooling. For example, at Finland data centre they use sea water cooling that is, they trap the hot air and cool their equipments with water. Another example is, at Belgium data centre they use evaporator towers and hence take the advantage of evaporative cooling. Also they use natural cooling power of sea water and save and recycle water.
The fourth step they implement is optimization of power distribution. They design the data centers in such a way that they consume as little energy as possible by minimizing the power loss and removing unnecessary parts. They optimize the power path. Atypical server wastes about one third of energy. It uses UPS (Uninterruptible Power Supply). The power supply is converted from AC to DC and then supplied to UPS and when the UPS power is backed up the DC is converted back to AC and then again from AC to DC and then finally to server.




Typical data center power usage system

The Google servers have annual savings of over 500kWh per server or 25% over a typical system. Google also customizes servers to stick with essentials only.


Google data center power usage system

**5. CASE STUDY OF SOUTHEASTERN DATA COMPANY**

Founded in 1996, Southeastern Data provides local, national, and international organizations responsible and cost-effective solutions for their electronic waste challenges. The Southeastern Data is an Environmental Protection Agency (EPA) registered and Florida Department of Environmental Protection (FDEP) licensed and approved recycling company. The main offices are located in Columbus, Ohio and Orlando, Florida. Southeastern Data is an expert at recycling all forms of computer and electronics equipments.

With rapid development in electronics industry the electronic waste generation has also taken pace being high in numbers in the solid waste stream. Hence managing, recycling and disposal of this e-waste has become vital for our environment. It's miserable that the EPA reports state that e-waste in the U.S. has multiplied more than twice since the year 2000, and barely only 13% of e-waste is disposed properly. E-waste also contains valuable metal materials such as aluminum, iron, silver, copper and even gold in plenty amounts. Instead of transporting this e-waste to the landfills, the unwanted or damaged electronic equipment can be renovated, reused and recycled, conserving the natural resources and thereby minimizing the energy required in production of new electronic equipments. For instance, consider production of aluminum. If aluminum is recycled, it saves about 90% of the energy required in production of new aluminum. Recycling the electronic scrap makes more sense than just dumping the scrap into a landfill. Also this electronic scrap contains toxic materials such as lead and mercury and these materials have the potential to leach into and contaminate the soil and water. Hence it's obligatory to protect the surroundings with proper e-waste recycling and disposal.

More than 3.5 million tons of e-waste is generated in U.S. annually and this is why proper computer and electronic equipments recycling is very important. Southeastern Data has the resources, experience and the empirical data required to handle safely all the types of electronic recycling processes. [13]

**6. CONCLUSION**

The plan towards green IT should include new electronics products and services with optimum efficiency and all possible options towards energy savings. That is enterprise wise companies are laying emphasis on moving towards eco friendly components in computers, the use of eco-friendly sustainable components will become the norm rather the exception in future. Presently, with a greater concern for the environment, green computing is well practiced in most institutions and industries, and has contributed substantially to reduce carbon emissions and conserving the environment. To create awareness amongst the students many certifications and courses are too introduced. Also Government can discourage the irresponsible and improper disposal or dumping of computer hardware by putting in place a proper ICT (Information and Communication Technology) waste management body.

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