A Study on Needs and Measures to Implement Green Computing

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Abstract— *Go Green is a burning topic these days in order to save the planet earth. Green computing is an approach towards the minimization of usage of harmful materials and maximization of efficiency of energy during the lifetime of electronic goods with least or no impact on the environment. The objective of green computing is to reduce carbon emissions, promote recycling and biodegradability of electrical and electronic devices and factory waste. This paper formerly gives an introduction to Green Computing/Green IT. The rapid growth of technology, usage of computers and internet in our day to day life has a great impact on the environment. The main reason of the impact is carbon dioxide which is released by each operation which we do using the computer. The need of the hour is implementation of Green Computing. This paper includes the research about the key issues related to green computing. Many national and international IT related firms are taking steps to reduce the damage caused because of their IT operations. Finally, this paper discusses the different measures to implement green computing which can be taken to overcome the environmental issues and how to make a sustainable green computing plan. Green computing also encourages recycling of electron equipment reducing the usage of energy by both individuals and businesses.*

Keywords: *Green computing, Environment, Recycle, Energy Star, Carbon dioxide/Co2, E-waste.*

1. INTRODUCTION

As the Earth's Climate System temperature was rising up, a new environmental issue has come up which was named as Global Warming. During that period a new spot appeared on IT. Businesses and governments were working to balance growth with environmental risks. They were called to make IT systems and use IT in innovative ways to address environmental problems. IT was a solution and emerged as a problem for environmental sustainability. Even IT industry has become a significant contributor of to global warming. This problem has resulted in a new study and practice called Green Computing.

Green IT /Green Computing means " efficiently and effectively with minimal or no impact on the environment" designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems " [1]

Green Computing is the study and practice of eco-friendly devices and using the computing resources efficiently. It includes all the dimensions of environment sustainability, total cost disposal, cost of recycling and economics of efficient usage of energy.

2. HISTORY OF GREEN COMPUTING

Although the term Green Computing/Green IT has become popular and important now a days, but its theoretical origin is almost two decades old. In 1992, the U.S. Environmental Protection Agency launched Energy Star, a voluntary labeling program which is intended to support and recognize energy-efficiency in display units/monitors, climate control equipment, and other technologies. And it has resulted in the widespread adoption of sleep mode among consumer electronics. [2]

At the same time, the Swedish organization TCO Development launched the TCO Certification program to promote low magnetic and electrical emissions from CRT-based computer displays; this program was later expanded to include criteria on energy consumption, ergonomics, and the use of hazardous materials in manufacturing the systems. [2]

A milestone in the history of green computing is the Kyoto Protocol (1997) to the United Nations Framework Convention on Climate Change. [3] This protocol made computer manufacturers to undergo energy audits in order to calculate the electricity consumed by the computer devices during its lifetime and amount of carbon dioxide emission to take remedial measures.

Later on, in 2003 European Union adopted Restriction of Hazardous Substances (RoHS). This has become a landmark in the history of green computing. RoHS restricts the usage of lead, mercury, cadmium, hexavalent chromium, biphenyls, and diphenyl ether in the manufacture of electronic and electrical devices. [4]

These regulations and restrictions forced the manufacturers to use non-hazardous materials in the production of peripherals/ devices–chipsets, processors etc.

Green Computing Impact Organization (GCIO) is a non-profit organization and is involved in assisting the end users of computers and other electronic devices about improving the efficiency of green computing products. They educate the end users about the services of environmentally sustainable systems. [5]

3.   REASON TO ADOPT GREEN COMPUTING

Now a day's computer and internet usage has become a basic need of every educated individual since it has made our life easier and saves time and human effort in every work they do. But the same need is driving us towards adopting green computing. Reasons are many but a few as just listed below:

A typical desktop PC with a 17-inch flat panel LCD monitor requires about 100watts—65 watts for the computer and 35 watts for the monitor. If the computer is left on 24x7 for one year, the same system will consume 874 kilowatt hours of electricity enough to release 750 pounds of carbon dioxide into the atmosphere which is equivalent of driving 820 miles in a car. [6] This does not include the energy required for cooling the ambience. Conventionally, manufacturing of a computer also includes lead, mercury and other toxic materials. Two-fifth of the lead available in the landfills is used in manufacturing electronic and electrical equipment which is also one of the reasons for scarcity of minerals in the ground.
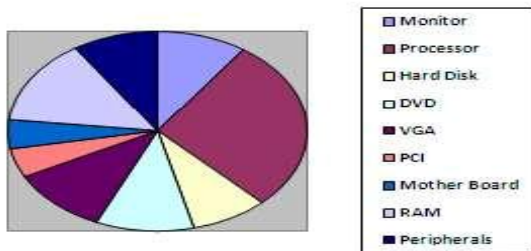

Fig. 1: Power consumption in a Pentium System

Data centers consume up to 10-100 times more energy because of the servers, critical computing systems, cooling system, power distribution units and hosting. Data centers and personal computers consume lots of energy due to the inefficient techniques and lack of sufficient cooling systems. These devices mostly generates carbon dioxide which is released in to the atmosphere [2]
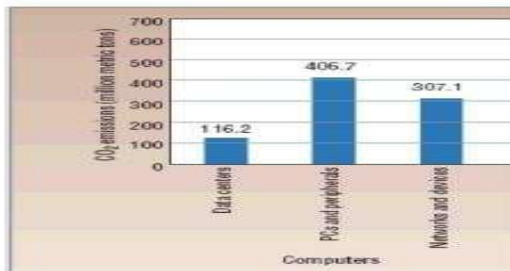

Fig. 2: Co2 Emissions [7]

The above figure clearly explains that huge amount of carbon emissions are through PC's & Peripherals.

2. Rapid increase in the usage of Internet:

As per the Internet World Stats, as on 31-Dec-2013, 2.8 billion people are using internet. And Asia is at the top having 45% of the entire users. This growth is estimating an increase in the demand of data centers by 25%. [8] Downloading, uploading data/music, online gaming, shopping, social networking, banking etc., need usage of internet. In addition to this even business are also using IT services in many business functions. Even government agencies also have adopted e-strategies which use web for public information, reporting or transactions. At present there is no area where we are not using internet [9].

3. Servers require approx. 1 to 1.5 watts of cooling for each watt of power utilized. Cooling power is directly proportional to server power requirements and will keep on increasing with the increase in data centers density. [9]

4. E-Waste
E-Waste is the short term for Electronic/Electrical waste. As per web encyclopedia e-waste is defined as discarded electronic and electrical devices. These e-wastes may include computers, TV's, LCD's, scanning devices, and mobile phones etc., which are disposed by their users. As per the report given by UNEP GRID Europe says that "e-waste today constitutes 5% of all the solid waste worldwide. [10] With the upgrading new technology hitting the market, more e-waste is generated. Most of this e-waste is recycled. And the remaining is ending up in the landfills. But we are all aware that landfills leak and the toxic substances which are used in the manufacturing of these devices contaminate the earth and ground water resources. [11]

Facts about E-waste

- A Chip whose weight is nearer to nothing generates a total of 89 pound of waste. Out of which 7 are hazardous and consumes 2,800 gallons of water. [1]

- During the creation of a monitor 139 pounds of waste is generated. [1]

- Circuit board whose weight is 4 pounds generates 40 pounds of hazardous waste. To create 2.5 pounds of copper for the circuit board, 280 pounds of copper sulphide ore is used. Boiling the ore to get pure copper produces SO2 which causes acid rain. [1]

- 40% of the landfills contain lead, mercury, cadmium and other toxic material which is coming from the discards of electronic devices. 1/70th of a teaspoon of mercury can contaminate a lake of 20 acres resulting the fish unfit to eat. [1]

4. IMPLEMENTING GREEN COMPUTING

A. Virtualization

Virtualization is the single effective way to reduce expenses while improving the efficiency of devices for large, middle and small enterprises. In the field of computing virtualization means creating a virtual version of something which includes operating system, hardware, storage devices etc. Virtualization is an optimization technique that rationalizes the usage of computing resources thus reducing the harmful effects on the environment. With virtualization a system administrator can combine several physical systems into virtual machines on one single, powerful system, thereby disconnecting the original hardware and reducing power and cooling assumption. [13]

Virtualization can be at 4 levels [2]

- Level O–No virtualization
- Level-1: Logical virtualization presents the idea of sharing applications
- Level-2: Hardware resources can be shared across multiple logical servers.
- Level-2: Cloud Virtualization

Virtualization reduces carbon emissions due to lesser amount of materials consumed in manufacturing.

[13]Zero clients are ultra-thin client server based model where the end user has no local software and has little hardware. Zero clients do not contain any processor, memory or hard disks. Zero clients can last up to 8-10 year where as a conventional PC lasts up to 3-4 years

A thin client weighs 10-20% of a normal desktop PC. Packaging material required for shipping the thin client is 2.2-4.4 lbs. This reduce size of thin clients reduces the carbon emission caused during the transportation.

Electricity consumed in case of thin client is 10% less than the normal PC. Server virtualization reduces the electricity consumption, cooling requirements in the data centers. Therefore, virtualization reduces both costs and carbon emission.

B. Improving Algorithmic Efficiency

An efficient algorithm makes least use of resources with maximum increase in the productivity. A simple activity like searching some information using search engine can have an adverse effect on the environment due to the energy consumed and CO2 emission during the process. Thus, without improving the algorithmic efficiency, we can't expect much in terms of energy conservation even from cloud computing. [2]

C. Architectural Changes

Remodeling of the existing IT architecture should prove to be helpful in the long term. A plan needs to be created for the development of sustainable technology. This methodology is not limited to changing architecture of data centers but also other aspects like business operations, IT facilities, communications etc., should be taken into account. Currently used green initiatives may be a long term approach but the idea behind it remains the same. Changes in the architectural designs will maximize the accessibility to sophisticated technologies that cause least or no harm to our planet's resources. [2]

D. Cloud in Green Computing

Cloud infrastructure addresses two important aspects of green IT approach i.e. resource and energy efficiency. Cloud computing services help to reduce the carbon emissions and energy consumption. Cloud may be public or private or service, but computing will be greener. Cloud providers provide servers for millions of users maximizing the utilization of servers and reducing the total number of servers required.

Google has developed Gmail, a cloud based e-mail service used by more than 4 million organizations. To optimize the process of storing hosting, serving emails, Gmail uses less than 250mW per user. Comparison between the locally hosted email and cloud based e-mail is shown in the below figure [14]
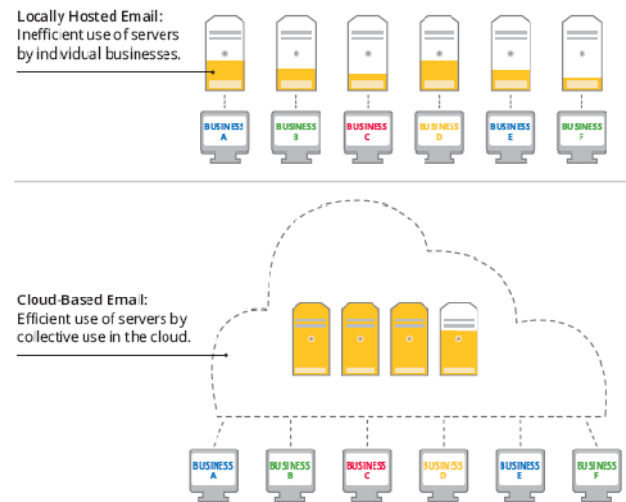

Fig. 3

Comparative analysis of energy usage among small, medium, large and Gmail cloud based service is given in the below table. [14]

Business Type	IT Power per user	PUE	Total Power per user	Annual Energy per user
Small	8W	2.5	20 W	175 KWH
Medium	1.8W	1.8	3.2 W	28.4 KWH
Large	0.54W	1.6	0.9 W	7.6 KWH
Gmail	<0.22	1.16	<0.25 W	<2.2 KWH

Shifting to cloud saves up to 90% of energy costs.

E. E-waste management

E-waste is generally found in landfills but there are certain safe options for disposing the old computers. [12]

- If your computer is in a working condition donate them to organizations like NGO's or trusts.
- If your system is not in a working condition send them back to the manufacturer. According the Greenpeace report 10 of 20 brands have a take back services: Samsung, HCL, Wipro, Nokia, Motorola, LGE, HP, Dell, Lenovo, and Zenith.
- For proper disposal of devices send them for recycling. Recycle old unused hardware using formal techniques.

E. Upgrading your computer to a green computer

Instead of buying a new computer we can improve the performance of the existing system with low consumption of energy by upgrading it to a green computer. To do this first check the entire system and check which part of the system has to be replaced easily except CPU. The biggest energy drain in any PC is the microprocessor, graphic card and the monitor. Have a quick evaluation. If you are using old CRT monitor then immediately replace it with a sleek LCD model. Using a LCD, in addition to low power consumption, we can get rid of toxic substances like lead mercury etc.

Upgrading the RAM helps your system process faster and reduces the overall power consumption.

If you are using a laptop, replace the battery with green battery. The best is the Boston Power Enviro battery which works with whole swing HP laptop models.

G. Use Energy Star licensed devices

ENERGY STAR is a U.S. Environmental Protection Agency voluntary program that helps businesses and individuals save money and protect our climate through superior energy efficiency. Energy Star licensed products are manufactured with the idea of less power consumption. With the help of Energy Star, by 2013, Americans have prevented more than 2.1 billion metric tons of greenhouse gases emissions.

Fig. 4: Energy Star logo

H. Go for an efficient system: Laptop vs. Desktop:

Desktops PC's are suitable for both offices and home but laptops are designed to consume less energy around 80% when compared to desktops.

I. Printers

Laser jet printers offer high speed and best quality when compared to ink jet printers. But an ink jet printer consumes 90% less energy than other printers. Always select a printer with duplexing mode i.e. the printer which prints on both the sides of the paper. Always turn off the printer when not in use.

J. Compact Disks

Always use rewritable CD's which can be used again and again. Green

Disk also provides CDs with 100% recycled packaging surrounding a new disk .

K. Power Management

The instructions to enable the power management feature on your computer:

PCs running Windows (2000, XP)

1. Right click on your desktop and a dialog box will appear
2. Select "properties"
3. Select "screen saver" tab
4. Select "energy saving features"
5. Select "settings"
6. Select the number of minutes you would like to keep your computer and your monitor on before the power down

Macs (OS7.1 - OS9, OSX)

1. Click on Apple icon
2. Select "control panels" in OS9 and "system preferences" in OSX
3. Select "energy saver"
4. Select "show details" in OS9
5. Check separate timing for display sleep
6. Select the number of minutes you would like to keep your computer and your monitor on before the power down.

L. Best practices when using a computer

- Switch off your computer when not in use
- Always put your PC/laptop in sleep mode. This mode save our session and put the computer in to low power state and allows us to quickly resume window. Sleep mode reduces 60-70% of electricity.
- Set an effective power plan.
- Turn down the PC/laptop brightness.
- Never use a screen saver, as it consumes electricity when computer is not in use.

Recent implementation in green computing

- Blakie is a search engine site powered by Google Search. When the screen is white or with colors system consumes 74W whereas blackie consumes 54W. If everyone switches for Google Search to Blackie, earth would save up to 750MW each year.

- Zombu computer is a new energy efficient PC which runs on Linux OS with 1.2 GHz processor, 512 MB RAM and consumes one third of power of light bulb.

5. COMPANIES SUPPORTING IN GOING GREEN

Hardware manufacturing Green Companies:

Following are the hardware manufacturing companies [15] which are involved in developing environment sustainable devices.

- HP programs to reduce greenhouse gases and toxic waste in their products

- Dell products are carbon neutral and uses 25% less power

- Intel focus is on increasing speed with low consumption of energy

- IBM follows formal Environmental policies since 1971

- Cisco Systems use 80% renewable energy

- AMD reduces their greenhouse gases and PHC emission. They are working on lead free products.

- Microsoft windows use less energy and uses virtualization techniques.

Newsweek has conducted a survey and has given ranks to the world's largest companies based on the corporate sustainability and environmental impact.

Table 1: Top 10 green companies in the world in 2014 [16]

Rank	Company Name	Country of HQ	GICS Sector	Energy	Carbon	Water	Waste	Reputation	Sustainability Themed Committee	Audit	Green Score
1	Vivendi	France	Telecommunication Services	73.3	67.8	94.6	82.9	87.7	Yes	Yes	85.3
2	Allergan	US	Health Care	72.2	85.2	61.1	82.0	100.0	Yes	Yes	85.1
3	Adobe Systems	US	Information Technology	82.7	87.1	99.2	91.9	51.4	Yes	Yes	84.4
4	Kering	France	Consumer Discretionary	69.7	70.2	81.5	82.2	90.1	Yes	Yes	83.6
5	NTT DOCOMO	Japan	Telecommunication Services	81.7	57.7	90.5	90.6	100.0	Yes	No	83.1
6	Ecolab	US	Materials	73.2	80.1	84.3	59.6	90.1	Yes	Yes	82.6
7	Atlas Copco	Sweden	Industrials	78.0	89.4	81.9	87.4	58.7	No	Yes	77.2
8	Biogen Idec	US	Health Care	69.2	82.7	84.5	97.0	53.4	No	Yes	75.7
9	Compass Group	UK	Consumer Discretionary	74.3	69.3	91.3	83.9	87.4	Yes	Yes	75.3
10	Schneider Electric	France	Industrials	73.0	71.9	79.5	68.0	57.0	Yes	Yes	75.3

Greenpeace Scores

According to the Greenpeace ranks given to electronic companies based on policies on different environmental issues Toshiba with score 5.3 is at the top. [15]

- Toshiba focuses on toxic elimination in their products.

- Apple with 5.1 score continues to improve toxic elimination and e-waste management.

- Sony is with score 5.1 for better energy totals

- HP with score 4.7 supports global emission reductions

Google is working hard on creating a web that is better for the environment. The company is going green by using resources efficiently and supporting renewable energy. Google data centers use 50% less energy than any typical data center. Google has committed over $1 billion to renewable projects. A business using Gmail decrease its environmental impact by 98% [14]

In order to facilitate virtual computing, Intel Corporation and AMD have built proprietary virtualization enhancements to the x86 instruction set into each of their CPU product lines.

The challenges of green IT is immense; however, recent developments specify that the IT industry has the will and conviction to tackle our environmental issues head-on. Companies can have profits by taking these challenges as opportunities to address environmental issues and adopt eco-friendly policies and practices

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