Green Computing: Awareness, Current Issues and best practices

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Abstract
The environment is the surroundings or conditions in which a human being, animal, or plant lives or operates. It is the sole responsibility of human being (a social animal) to safeguard the nature. With the invention of new technologies, there is a threat to the nature and resulted in global warming. Global warming means an increase in the earth’s average atmospheric temperature that causes corresponding changes in climate and that may result from the greenhouse effect. With Information Technology at its peak, it is also contributing heavily to global warming. Hence, Green computing. Green Computing is the study and practices of designing, manufacturing, using & disposing of computers, servers and associated subsystems of computers such as monitors, printers, storage devices and networking and communications systems efficiently and effectively with minimal or no impact on the environment. Most of the IT Companies / Departments are a source for excessive power use, excessive spending of resources and uses many toxic materials. In this paper we discuss about several issues in the Eco-System because of IT, Current Green computing Technologies, proposed practices and potential research areas in green computing (IT related).

Keywords: Green computing, global warming, practices.

I. INTRODUCTION

Now a days the People all over the World are facing a big issue known as “Global Warming”. So each and every one of us is responsible to protect our World/Earth from Global Warming (refer figure 1).

Figure 1: together we do

In 1992, the US Environmental Protection Agency launched Energy Star (refer figure 2), a voluntary labeling program which is designed to promote and recognize energy efficiency in monitors, climate control equipment, and other technologies. Later Australia, Canada, Japan, New Zealand, Taiwan and the European Union have also adopted the program [7].

Devices carrying the Energy Star logo, such as computer products and peripherals, kitchen appliances, buildings and other products, generally use 20%–30% less energy than required by federal standards.

Figure 2 Energy star

After the Energy Star Program started the people all over the world got some awareness about “Save Energy”

II. GREEN COMPUTING – WHY?

Computer manufacturers and vendors contribute directly to pollution, whereas the IT industries have a hidden impact on environmental pollution caused by unconscious consumption of power and inefficient use of hardware devices (Agarwal, Datta & Nath, 2014, p. 5). The ICT industry is responsible for about 2% to 2.5% of all world’s greenhouse gas emissions. Although it is not a large percentage, very disturbing fact is that the rate of ICT consumption is increasing by 20% a year so if nothing is done the contribution to global greenhouse gas emission is projected to nearly double to about 4% - in 2020.[2]

- computer energy is often wasted
- leaving the computer on when not in use (CPU and fan consume power, screen savers consume power)
- printing is often wasteful
- Most of us unnecessarily taking printouts and wasting the papers & ink/toners.

- pollution
- manufacturing techniques, packaging and disposal of computers and components makes pollutions.

- Toxicity

- There are toxic chemicals used in the manufacturing of computer components which can enter the food chain and water.

So, we have to follow green computing to Growing public environmental awareness, Increasing impacts on environmental, human health and Corporate social responsibility

The goals of green computing are

- Reduce the use of hazardous materials, Save energy and Recycle the products and factory waste.

Current Environmental Issues

A 450 watt server running 3,942 kWh/year produces 5.3 tons CO₂, a Car traveling 12,000 miles/year produces 4.4 tons CO₂ and a Commercial airliner making 6 round trips between Boston & Los Angeles produces 4.4 tons CO₂. We may think that only vehicles produce more pollutions but that may not be fully true. Among the above three the server only produces more CO₂.

Cradle to Grave Approach of a Computer

1. Manufacturing: Average desktop computer with monitor requires 10 times its weight in chemicals and fossil fuels to produce. 240 kg of fossil fuel for CRT monitor (United Nations University) 266 kg of fossil fuel for LCD monitor (Williams, 2003).

2. Use during lifetime: Simply leaving a computer on consumes electricity and adds to computing costs. It is estimated that a typical desktop PC with a 17-inch flat panel LCD monitor requires about 100 watts, 65 watts for the computer and 35 watts for the monitor. If left on 24x7 for one year, this same system will consume 874 kilowatt hours of electricity enough to release 750 pounds of CO₂ into the atmosphere and its equivalent to drive a car for 820 miles in an average. Energy Use of PCs: CPU uses 120 Watts, CRT uses 150 Watts. 8 hours of usage, 5 days a week = 562 KWatts. If the computer is left on all the time without proper power saver modes, this can lead to 1,600 KWatts.

3. Disposal and reallocation

Short product life expectancy is 2-5 years. Same toxins in manufacturing process can cause environmental contamination & Human health risks.

Chemical Elements Found in Computers and Components

Elements in bulk: lead, tin, copper, silicon, carbon, iron and aluminum

Elements in small amounts: cadmium and mercury

Elements in trace amounts:

Germanium, gallium, barium, nickel, tantalum, indium, vanadium, terbium, beryllium, gold, europium, titanium, ruthenium, cobalt, palladium, manganese, silver, antimony, bismuth, selenium, niobium, yttrium, rhodium, platinum, arsenic, lithium, boron, americium.

The following is the List of examples of devices containing these elements

Almost all electronics contain lead & tin as solder and copper as wire & PCB tracks. lead: solder, CRT monitors Lead in glass, Lead-acid battery.

The problems caused by the Chemicals available in the Computers are:

LEAD can cause damage to the central and peripheral nervous systems, blood system, kidneys, endocrine system and cause negative effects on child brain development. Lead accumulates in the environment and has toxic effects on plants, animals and micro organisms. Electronics contribute 40% of the total amount of lead found in landfills and can make its way from landfills into the water supplies.

Mercury spreads out in water transforming into methylated mercury which easily accumulates in living organisms. It enters the food chain through fish that swim in polluted waters methylated mercury can cause chronic brain damage.

Cadmium is classified as toxic, these compounds accumulate in the human body, particularly the kidneys. It is absorbed through respiration and also food intake. Cadmium has a half-life of 30 years so that cadmium can poison a human body slowly through the human’s life.

The plastics in computers are often treated with flame retardant chemicals, particularly brominated flame retardant these chemicals can act as endocrine disrupters and increase risk of several forms of cancer. They have been found entering the food chain. E-Wastages (refer figure 3) causes Land Fills and the above dangerous health problems.

![Figure 3: ewaste](image-url)
Households are Big Contributors to Climate Change: 40% of all greenhouse gas emissions come from households like Vehicles, Home Heating & Electricity.

**Carbon dioxide stays in the atmosphere for approximately 100 years, methane lasts about 12 years. Other greenhouse gases last even longer.**

According to Bentley University (2012), it has been reported with the chart below (figure 4) on the Carbon footprint analysis from the year 2006 to 2012. We can understand that they have been declining on CO2 emissions as compare to 2008 at 10% and this is as a result of awareness on green computing. And in 2012 despite an increase in campus space etc the result still declined to 8%. With the current rate of decline in carbon emissions, its sure that it will decline in the future years also.

![Figure 4: carbon footprint](image)

III. CURRENT GREEN COMPUTING TECHNOLOGIES

IT Products and eco-labeling

There are several organizations in the world which support eco-label IT products[3]. These organizations provide certificates to IT products based on factors including design for recycling, recycling system, noise, energy consumption etc.[4]

**Zonbu Computer:**

The Zonbu is a new, very energy efficient PC. The Zonbu consumes just one third of the power of a typical light bulb. The device runs the Linux operating system using 1.2 gigahertz processor and 512 meg of RAM. It also contains no moving parts and does even contain a fan.

**Sunray thin client:**

Thin clients like the Sun Ray consume far less electricity than conventional desktops. A Sun Ray on a desktop consumes 4 to 8 watts of power, because most of the heavy computation is performed by a server.

**E-Waste Recycling**

Discard used or unwanted electronic equipment in a convenient and environmentally responsible manner. Computers have toxin metals and pollutants that can emit harmful emissions into the environment as seen above. Recycling computing equipment such as lead and mercury enables to replace equipment that otherwise would have been manufactured. The reuse of such equipments allows saving energy and reducing impact on environment.

**Data Center Consolidation & Optimization**

Currently much of the emphasis of Green Computing area is on Data Centers, as the Data Centers are known for their energy requirements and wasteful energy consumptions. With the purpose of reducing energy consumption in Data Centers it is worthwhile to concentrate on the following:[5]

**Information Systems:** Efficient and right set information systems for business needs are a key in building Green Data Centers. As per green computing best practices efficient servers, storage devices, networking equipments and power supply selection play a key role in design of information systems.

**Cooling Systems:** It is suggested by the researchers that at the initial stage of design process for data center cooling systems, it is significant to consider both current and future requirements and design the cooling system in such a way so it is expandable as needs for cooling dictates. Standardized environment for equipment is must for Data Center Air Management and Cooling System. Consider initial and future loads, when designing & Selecting data center electrical system equipment.

Some companies that are practicing Green Computing

According to the company sources, IBM in 1990 saved around 4.6 billion kWh of electricity and prevented almost 3 million metric tons of CO2[8] emissions. So, essentially a reduction in wastage and recycling of the used materials is what is required to ensure green IT. There have been multiple approaches to green computing[6]. Data center servers use 50 times the energy per square foot as an office says Mark Bramfitt, principal program manager at PG&E[8]. Data centers are the main reason behind energy consumption. Energy consumed by data centers in the United States and worldwide doubled from 2000 to 2005, according to Jonathan Koomey, a consulting professor at Stanford University and staff scientist at Lawrence Berkeley National Lab. As a result, some companies are chasing cheaper data center power. Google is building a data center on Oregon’s Columbia River to tap hydroelectric power, while Microsoft builds nearby in Washington for the same reason. Green houses gases naturally blanket the earth are responsible for it’s more or less stable temperature. [1]. To keep servers at the right temperature, companies mainly rely on air-conditioning equipments. The more powerful the machine is, the more cool air is needed to keep it from overheating. By 2005, the energy required to power and cool servers accounted for about 1.2% of total U.S. electricity consumption, according to a report released in February by staff scientist Jonathan Koomey of Lawrence Berkeley National Laboratory and sponsored by chip manufacturer AMD. The Energy Star program encourages manufactures to create energy-efficient devices that require little power are not in use. For
example, many devices switch to standby mode after a specified number of inactive minutes.

VIA technologies Green Computing

VIA Technologies, a Taiwanese company that manufactures motherboard chipsets, CPUs, and other computer hardware, introduced its initiative for “green computing” in 2001. With this green vision, the company has been focusing on power efficiency throughout the design and manufacturing process of its products.

IV. PROPOSED PRACTICES TO IMPLEMENT GREEN COMPUTING IN OUR DAILY LIFE

1. Use Energy star Products only
2. Switch off the devices whenever not in use.
3. Remove the USB Devices whenever not in use.
4. Turn off Wifi / Blue Tooth whenever not in use.
5. Use Sleep Mode settings in your system, don’t use Screen saver, it will not save energy.
6. Enable Hibernate Mode - Hibernate mode saves energy and protects your work by copying system data to a reserved area on your hard drive and then completely turning off your computer. When you turn on back, your files and your documents appear on your desktop just as you left them.
7. The following techniques speed up your systems & reduce energy consumption.
   a. Disable Unwanted Services which are running in the background using Services option in the control panel / msconfig command.
   b. Service your processor’s cooling fan at least 6 months once.
   c. Delete the .tmp files in your system frequently.
   d. Do Hard Disk Defragment at least 3 months once.
8. Try to use Solar / Hydraulic / Wind Energy
9. Whenever possible use mobiles instead of computers, which consume less energy.
10. Implement power management options on your machines
11. Reducing the overall “on” time of the system as much as possible.
12. Reducing the overall “on” time of the monitor.
13. For downloading use some Download Accelerator Software for fast download to reduce Computer on time.
14. If you are not going to use your laptop for more than 2 weeks, remove the laptop battery and keep it in a safe place to increase the lifetime of the battery.
15. Tips for Printer
   1. Replace paper with digital documents & digital signature
   2. Use Garamond font to save printer ink/toner [9]
   3. Turn off your printer using the on/off switch on it before turning it off at the mains. The likelihood is that your printer will park the ink cartridges and cap them so that they do not dry out.
   4. Check your document for mistakes. once you’ve hit print then you’ll have wasted all that ink, paper and you have to print again.
   5. Use your printers Fast Draft/EconoFast setting. Unless you’re printing something where quality is required.
   6. Before you print anything, make use of the preview option and check whether things look good. At this point you may decide to manually change the settings, for example print several pages on one piece of paper, reduce the size of an image etc.
16. Reuse: donate your computer / components to people who may not have.
17. Upgrade: Rather than discarding your computer when the next generation is released, just get a new CPU and RAM [if possible], upgrade rather than replace while you will still be discarded some components, you will retain most of the computer system (e.g., monitor, keyboard, mouse, cables, etc.)
18. Use LED / LCD monitors instead of CRT.
19. Use CFL bulbs (refer figure 5) instead of normal bulbs. Replacing just 1 incandescent light bulb with 1 compact florescent bulb saves about 150 pounds of carbon dioxide per year.

![Figure 5](image)

20. Use video conference and remote computer administration to reduce transportation emissions. Reducing transportation costs by supporting team work and meetings thus minimizing the CO2 emissions.
21. Reduce our consumption of fossil fuels. Because greenhouse gas emissions are tied very closely to our energy consumption, using less fossil fuel based energy puts fewer greenhouse gases into the atmosphere. This will help to slow the global warming.

Manufacturer – side

Greener technology:- PBDE-free plastic ,lead-free soldering ,fewer toxic solvents . Plastics labelled with recycling codes ,Less material used.

Architectural Recommendations
Nano-Data Centers (NaDa):


Energy Proportional Computing (EPC):

Servers & computers typically operate at 10%-50% of utilization. Eliminates baseline power waste. Technology present in mobile device.

Implementing Cloud Computing as much as possible:

Works hand in hand with NaDa and EPC. Distributes workload over many devices. Allows instant access to files from anywhere any time.

By using the following methods (refer Table 1) to surf the internet using Google Chrome will reduce the machine usage time & energy cost.

Table 1: Google chrome keywords

<table>
<thead>
<tr>
<th>Sln No.</th>
<th>Keyword</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>&quot; &quot;</td>
<td>Use quotes to search for phrases &quot; &quot;</td>
<td>“Green Computing &quot; &quot;</td>
</tr>
<tr>
<td>2.</td>
<td>+</td>
<td>If you would like to include the words in search results the include “+”</td>
<td>“India” + “democracy”</td>
</tr>
<tr>
<td>3.</td>
<td>-</td>
<td>If you would like to exclude the words in search results the include “-”</td>
<td>“India” “-” “Politics”</td>
</tr>
<tr>
<td>4.</td>
<td>AND</td>
<td>retrieve the results , only if it contains combination of all words</td>
<td>“Indian” and “politics”</td>
</tr>
<tr>
<td>5.</td>
<td>OR</td>
<td>Retrieve the results , even any of the word contains</td>
<td>“Indian” or “politics”</td>
</tr>
<tr>
<td>6.</td>
<td>Site</td>
<td>Google will restrict the results to those websites in the given domain.</td>
<td>help site:www.google.com will find pages about help within <a href="http://www.google.com">www.google.com</a></td>
</tr>
<tr>
<td>7.</td>
<td>Filletype</td>
<td>Searches for a particula file type</td>
<td>Dr.Nic filetype:ppt x</td>
</tr>
<tr>
<td>8.</td>
<td>Inurl</td>
<td>Google will restrict the results to documents containing that word in the url.</td>
<td>inurl:google search - will return documents that mention the word &quot;google&quot; in their url, and</td>
</tr>
<tr>
<td>9.</td>
<td>Allintitle</td>
<td>Google will restrict the results to those with all of the query words in the title</td>
<td>allintitle: google search - will return only documents that have both &quot;google&quot; and &quot;search&quot; in the title.</td>
</tr>
<tr>
<td>10.</td>
<td>Cache</td>
<td>Google will highlight those words within the cached document.</td>
<td>cache:www.google.com web will show the cached content with the word &quot;web&quot; highlighted</td>
</tr>
<tr>
<td>11.</td>
<td>Link</td>
<td>The query [link:] will list webpages that have links to the specified webpage</td>
<td>[link:www.google.com] will list webpages that have links pointing to the Google homepage</td>
</tr>
<tr>
<td>12.</td>
<td>Related</td>
<td>will list web pages that are &quot;similar&quot; to a specified web page</td>
<td>[related:www.google.com] will list web pages that are similar to the Google homepage</td>
</tr>
<tr>
<td>13.</td>
<td>Info</td>
<td>will present some information that Google has about that web page</td>
<td>info:www.google.com will show information about the Google homepage</td>
</tr>
</tbody>
</table>
Using shortcuts (refer table 2) in our computer can save us a lot of time [Computer usage time] instead going every time for mouse. By using the following short cuts we can surf the web in a faster and efficient manner.

<table>
<thead>
<tr>
<th>Short cut</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ctrl + N</td>
<td>to open a new window (or just pull the tab outside)</td>
</tr>
<tr>
<td>Ctrl + T</td>
<td>to open a new tab</td>
</tr>
<tr>
<td>Ctrl + Shift + N</td>
<td>to open Incognito Window</td>
</tr>
<tr>
<td>Ctrl + O</td>
<td>to open any file</td>
</tr>
<tr>
<td>Ctrl + L</td>
<td>to select the URL</td>
</tr>
<tr>
<td>Ctrl + D</td>
<td>to bookmark the visited webpage</td>
</tr>
<tr>
<td>Ctrl + U</td>
<td>to view the source of the webpage</td>
</tr>
<tr>
<td>Ctrl +/-</td>
<td>to zoom in or out (&quot;Ctrl + 0&quot; for normal size)</td>
</tr>
<tr>
<td>Ctrl + P</td>
<td>to print the webpage</td>
</tr>
<tr>
<td>Alt + Home</td>
<td>to visit home page of the current window</td>
</tr>
<tr>
<td>Ctrl + W</td>
<td>to close the current tab</td>
</tr>
<tr>
<td>Ctrl + Tab</td>
<td>to switch tabs</td>
</tr>
<tr>
<td>Ctrl + H</td>
<td>to view history</td>
</tr>
<tr>
<td>Ctrl + J</td>
<td>to view downloads</td>
</tr>
<tr>
<td>Ctrl + F</td>
<td>to search your text in current window</td>
</tr>
<tr>
<td>Alt + F</td>
<td>to open browser</td>
</tr>
<tr>
<td>Shift + Esc</td>
<td>to open browsers</td>
</tr>
<tr>
<td>Ctrl + shift + T</td>
<td>to open recently closed tab</td>
</tr>
</tbody>
</table>

Table 2: short cut & description

Since now computer has become an essential electronic gadget in everybody’s life, Practicing Green computing has become part and parcel of our life too. By exercising the above suggested methods every human can contribute himself / herself to reduce global warming and can Save the future World for our next generation. In addition to that all of us can work and try to contribute towards the research of IT related areas that can help practice green computing and thereby reduce global warming.

- Using IT to reduce carbon emissions
- Power-aware algorithms and protocols
- Power-aware software and hardware
- Life-cycle analysis of IT equipment

REFERENCES