A Six Point Charter of Green Computing

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ABSTRACT

Computing is fast calculations and generating solutions to complex problems. Recently Researchers have started focusing on energy efficiency, minimization of power consumption in e-equipments. Researching on environmentally sustainable factors is an emerging trend where Green computing is the efficient utilization of computing resources. It aims at reducing the use of hazardous materials, promoting recyclability or biodegradability of defunct products. "Green Computing" is also minimization of e-waste and use of non-toxic materials in preparation of e-equipments. IT industry is a complex mix of people, networks and hardware. The industry consumes approximately 3% of the world's energy which increases constantly. Green computing has become a paramount requirement for the protection of the environment. The implementations need to study gains that can be achieved, analyze gaps in achieving the benefits of green computing. The Organization for Economic Co-operation and Development (OECD) in its survey listed over 90 government and industry initiatives on "Green ICTs" since both are needed to "go green" thus prolonging energy resources.

General Terms

Green Computing, Green ICT

Keywords

E-waste, Toxic, Eco-Friendly, Bioplastics, Green Computing, Sustainability, Energy Efficacy.

1. INTRODUCTION

Green computing is "the study and practice of designing, manufacturing, and disposing computers and communications systems efficiently with negligible impact on the environment [1]. The objectives of green computing are reducing the use of hazardous materials, maximizing energy efficiency and ensuring recyclability of a redundant product. Current Computing is not eco-friendly though there are many ways of going green in computing. Human activities in Computing which require environmental savings can be achieved by implementing straight-forward measures in hardware. Only two of the major PC and electronics manufacturers obtained a green rating in 2010. Researches into key green areas like making energy-efficient computers, algorithms and technologies will help the green initiative. The current scenario of green computing is encouraging mainly due the efforts by businesses to cut down costs related to electricity. Public and corporate opinions are shifting in favor of environmental responsibility. Software to measure and reduce carbon emissions resulting from computers are available. Common concepts in Green computing include Virtualization, Power Management, Recycling and Telecommuting and stages include Strategy, Design, Implementation, Operations.

This paper is a sincere effort to study and advice simple ways of following green computing initiatives.

2. HISTORY OF GREEN COMPUTING

Green Computing is a paramount Requirement for today's computer world. The Green computing initiative goals of energy-efficient Microprocessors, servers and peripherals and appropriate disposition of electronic waste, dates back to 1992. U.S. Environmental Protection Agency launched Energy Star labeling program to promote and recognize energy efficient computer monitors, climate control equipments, and other technological gadgets. A wide spread response resulted in the sleep mode in consumer electronics. The Energy Star Program included stricter efficiency requirements for computers and a tiered ranking system for approval in October 2006. The European Union's directives 2002/95/EC and 2002/96/EC specified reduction in hazardous substances of heavy metals and flame, making the manufacturers undertake responsibility of collecting and recycling of their defunct equipment Almost concurrently, TCO Development a Swedish organization launched a Certification program to promote reduction in magnetic and electrical emissions of CRT-based computer displays. Present day processors use more power and the heat dissipated increases temperature of the rooms. This heat causes the CPU's to crash often at higher temperatures. Moreover, Data center servers are energy eaters since they use approximately 50 times the energy of any other office. Google and Microsoft are building data centers near Rivers to use hydroelectric power. At least Twenty Six states of the US have a recycling program for obsolete computers and consumer electronics equipments. In 2010, the American Recovery and Reinvestment Act (ARRA) was signed and allocated over $90 billion for green initiatives and in 2010, U.S. Energy Department granted ARRA money with the aim of improving energy efficiency in data centers. Many governmental agencies are implementing these standards and regulations for encouraging green computing.

3. BECOMING GREEN

Computer manufacturing includes lead, mercury, cadmium and other toxicants. A minimum of 1.8 tons of chemicals, fossil fuels and water are required to produce a typical desktop computer [2] which contain 4 to 8 pounds of lead. The Computer Weekly article of 2006, reported a Carbon Trust of office equipment to 15 per cent of total energy use in UK[3]. The (ICT) industry accounts to 3% of carbon dioxide emissions globally which is equal to Co^2 emissions of the aviation industry [4]. To respond to this growing pollution threat modified business establishments can minimize the undesirable impact on the environment. Virtualization is a very cost-effective and energy efficient tool for green computing where applications are divided between virtual machines increasing server utilization. Highly Efficient

processors are another critical energy-saving element. Execution of related tasks as continuous blocks allowing the hardware to be off at other times saves energy. Using Flat panel monitors instead of CRT monitors, avoiding screen savers are very small but great steps to go green. Power consumption can also be reduced by using low capacity flash based devices, instead of hard drives or by avoiding two-sided printing thus reducing paper consumption are again steps every computer user can follow.

3.1 User level Green computing

Personal computer is an easy target for beginning the green initiative. Any Desktop PC wastes over half of the power delivered to it [5].

- Shutting down the Computer: Shutting down, sleeping, or hibernating a computer when not in use conserves energy. Simple guidelines like setting the Monitor/display to sleep after 20 minutes or less, setting the Hard drives sleep time to 20 minutes or less helps the user green initiative. Disabling screen savers or set the system to hibernate saves a lot of energy. Set the computer to optimal energy use.

- **Saving Print Paper** : Proof reading on the system till the final print is avoiding unnecessary print copies saves paper and printing ink. Removing unnecessary pages or space from the document. Leaving a desktop printer off when not in use, Setting smaller margins to maximize paper efficiency, printing double sided and using fonts which consume lesser ink, confirms that a user is going green.

- Turning on Peripherals only when needed: Peripherals draw a minimum power when on. It is better to have a separate switch for the peripherals so that they can be turned off when not required.

- Defining the power usage: Users can reduce the amount of time spent on computers, while maintaining their productivity. Estimate the power usage of system and define a strict schedule for working on system, eliminating the idle hours the system will be on. Follow the simple steps like turn on computer/ monitor/ power management features in the operating systems. Fig.1 describes the power consumption of computer and allied equipments in terms of watts used. The copiers top the chart on energy usage, Servers and Laser printers are placed an equal second. Portable Laptops consume the least energy.
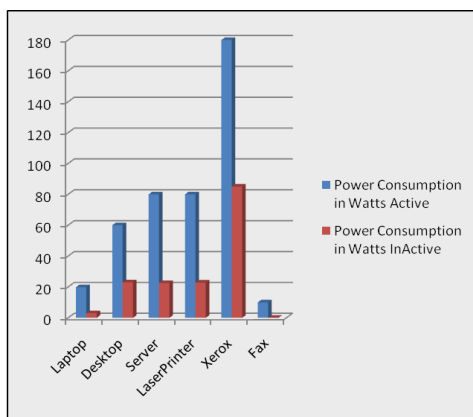
Fig 1: Power Consumption in Watts of Computer Equipments

- Using Power Saving Micro-processors: Identifying Microprocessors that consume less wattage is a very good green initiative. Manufacturers like Intel, AMD and Sun Microsystems have adopted the green religion and are increasing chip efficiency in their new high-end servers. For Ex. Ultrasparc 1 uses 60-62 watts, Niagara 2 chip 80 watts. Setting the Power Options of the computer to switch to sleep mode, when not in use is a good practice. The user can find the power options settings in PC's Control Panel to go to the stand-by mode. Shutting down hard drives when not is use or downsizing the system to accommodate the exact requirements are again great user level green initiatives. Developed markets have a lower percentage increase but require large amounts of power [6]. Fig. 2 Explains the power consumption by category of computer servers and allied equipments. Servers and printers consume a major portion of energy and amounting to 49% of the energy requirements. PC's come second with 39%.
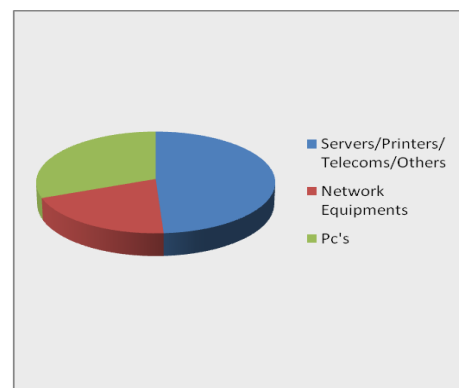
Fig 2: Energy Consumption of Computer Categories

- Ensuring Energy-Efficiency: The users can choose options that saves money and energy thus reducing environmental impact. Laptops, LCDs and ink-jet printers use less energy. Ensuring Energy Star label in electronics appliances is a great green initiative since they have 40% to 70% energy saving options.

3.2 Organizational Green Computing

Green technology also referred to as environmental technology is preserving natural resources and the environment. It is the future society in its starting stages. The most important objective of green technology is to innovate ways of non-damage to the Earth's natural resources. The use of green technology is aimed at limiting the wastage and reducing the pollution created during production and consumption. Green computing is using computing resources efficiently for the Earth to be healthy. Organizations have a larger role to play in Green computing or green technology. Leaving the computer on when not used generates energy wastage as the CPU and the cooler fans consume power. About 60 per cent of office PCs in US is left powered on resulting in billions of kWh of electricity wastage and tons of carbon dioxide emissions [6]. There are simple ways of practicing green computing within organizations. Measures like turning off idle PCs, turning off screens when not in use are simple but highly effective measures. Desktop computer power supplies (PSUs) are 70–75% efficient and dissipate

heat. 80 PLUS specifies 80% efficient PSUs as replacements for older, less efficient PSUs [7]. Hard disk drives consume lesser power per gigabyte than physically larger drives. Solid-state drives store data in flash memory or DRAM reduce power consumption since they have no moving parts. Due to reduction if hard disk prices, storage farms increase their storage capacity to make more data available online, thus increasing power consumption. Green computing participation can be in terms of developing solutions that align IT processes with principles of reduce, reuse, and recycle. Key to saving is reducing the power used by a computer. At the operating System level, The Microsoft Windows Operating system had limited PC power management features and initially provided stand-by (suspend-to-RAM), low power state monitor options. Windows added hibernate (suspend-to-disk) and support for the ACPI standards and power management in Windows and Windows XP. Windows Vista redesigned the power management. Windows 7 has an efficient use energy. Energy-efficient display options include, using a shared terminal, thin client, or desktop sharing software instead of a Display card. Organizations need to keep servers at the right temperature and they mainly rely on air-conditioning equipments. Greater the power of the server more cool air needed to keep the server from overheating. Organizations can find innovative ways of using business processes to deliver sustainability. Usage of recycled used ink and toner cartridges can again largely benefit the environment. Computers and their energy sources can be run from non-conventional energy sources. The non-usage of video card or shared terminals amongst users, using a thin client / desktop sharing software are all again organizational initiatives to go green. Older video cards can be replaced in existing systems, since most of them may not require a dedicated heat sink or a fan. Organizations can formulate awareness programs for targeting major green technology issues like minimizing the energy consumption of the organization (minimizing the power bill), Using non-toxic material in equipments to work safer, minimizing health problem by occupational hazards.

3.3 Eco-friendly Computing

Reliability in the use of green materials in computers is one of the biggest and singular challenge of the electronics industry. Electronics giants can create eco-friendly computers aimed at reducing the e-waste in the environment, making it free from hazardous materials, PVCs or heavy metals (lead, cadmium, mercury). IT vendors can also go green for New revenue opportunities. The go green initiative also projects organizations as good corporate citizens in the eyes of the world. The Sun's Eco office takes care of their green initiatives. Dell has a "Plant A Tree For Me" initiative where consumers pay to plant new trees with the idea of offsetting computer emissions. There are many fundamental steps to decrease the environmental impact of computing, mainly involving measures for reducing energy consumption like Lower power hardware, better repair, re-use, recycling and Less pollutant manufactures who can be identified from web sites like GreenwashingIndex.com and StopGreenwash.org. CRT monitors use more power than LCD monitors and contain significant amounts of lead. Fluorescent back-lights have mercury, whereas LED back-lights do not have mercury. Hazardous chemicals like lead, mercury, cadmium, beryllium, brominated flame retardants (BFRs) and polyvinyl chloride (PVC) are used to make computers. Reductions in their use could prevent people being exposed to them and safely recycle electronic waste. Less polluting manufacturing

processes need to be undertaken by. ASUS computers have used bamboo for plastics in their computer casing.

4. DEVELOPING A GREEN PLAN WITH EXISTING RESOURCES

Every big change starts with a set of small initiatives. Simple initiatives like avoiding repeated printing, printing out only after completion, avoiding printing of emails for record and avoiding any kind of repetitive printing are measures that will produce great results in terms of environmental savings. Listed below are a few factors worthy of thought

- **Practice:** Green computing is best when the power usage is reduced with minimal paper consumption, defined recommendations for new equipment and recycling of old machines. Developing a longstanding green computing plan consisting of defined guidelines as recycling policies or proper recommendations for the disposal of used equipment.

- **Recycle:** Disposing unwanted electronic equipment in an environmentally friendly way, since, Computers have toxic metals and pollutants that produce emissions harmful to the environment. Instead of discarding computers in a landfill, they can recycled through their manufacturers.

- **Purchase Environment friendly Products:** Purchase EPEAT (Electronic Product Environmental Assessment Tool) registered products promoted by the nonprofit Green Electronics Council. EPEAT help assess, compare or choose products based on environmental attributes like desktops, notebooks and monitors. They also provide a set of reliable performance criteria for the design of products.

4.1 The six point charter for sustainability

Computing as an industry is a major problem for green computing. Computing technologies have not been environment friendly. Toxic chemicals are used in the manufacturing of computers and their packing's. Disposal of computers and components causes pollution. The industry has the solution in itself, since Computers and computing industry can help humanity reduce environmental impact by being more efficient. An application can **increase the business efficiency** by reducing the processing time and also improve on its usage and disposal. Fig 3 indicates a fair amount of practicability for green computing.
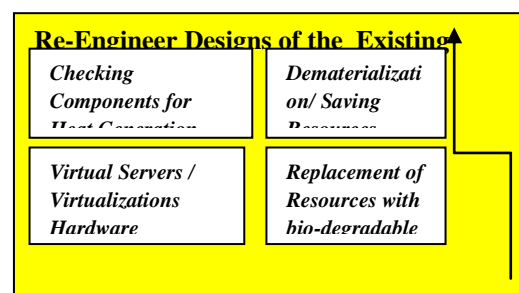
Fig 3: Factors for Sustainability

4.2 Checking existing system components

Heat generated by a computer depends on several factors like the CPU, add-on cards (attached to the system) like PCI cards, the activity of the Hard Disks and other intensive parts. The Microprocessor is a major source of heat. Even when

processor usage measures below 10% , Harder the Microprocessor works (60% or 80% or 100%), more the power usage of the CPU and more the heat generated. A desktop machine may access a Hard Disk Drive for a few seconds and have long periods of inactivity. On the other hand a server may continuously access the Hard Drives. Hard drives energy consumption is constant, the drives spin constantly with a constant amount of heat. Fragments in Hard Disk storage create excessive disk reads to find data. Defragmenting the disk regularly reduces the movement required to access files, thus reducing the heat. Electrical devices operate less efficiently with age and need more power. CPU coolers have a cheaper aluminum heat sink with higher speed fans to keep the CPU cool. Though Copper is expensive, it is very efficient at conducting heat than aluminum.The efficiency of work done on a computer can be indicated using

$$\text{Work}_{\text{Done}}/\text{Work}_{\text{Assigned}}*100\%.$$

In terms of power consumption, For example, a power utilization of 200 watts for 8 hours for a year would result in 584 kilowatt-hours of energy. In computers, a screensaver cannot save any energy. Energy is saved in sleep or standby modes, Hit intensive websites like google use multiple servers. Google has a solar system installed to power its servers, making it green computing compliant and increasing their efficacy. Specify power saving measures like "shut down the drives after a defined minutes of inactivity. Try to find new ways of maintaining older shape with lesser heat generation for sustainability.

4.3 Re-Engineering the Design

 Environmental sustainability design and reducing environmental impact continuously, is an uphill task. To achieve a sustainable product requires high levels of commitments right from Designs where architects need to realize the impact on the environment. The impact measurement is usually measured in tCO2eq (metric tons of CO2 equivalent) on the energy source and amount consumed. The power usage of a PC can be approximated to 200-400W depending on the CRT. A desktop machine plus a CRT monitor consumes approx 500W. Data centers have a very high energy demand. Virtualization reduces power consumption. Increase in rack power density without a cooling architecture is a definite data center disaster. Data centers can be downsized based on consumption wattage. When the government set a minimum 10% reduction target for data center energy usage by 2011, Google Inc. reduced its energy consumption to 50% with the aid of ultra efficient evaporative cooling technology. The Re-Designs of the motherboards with lower wattage supply and lesser consumption can be re-looked at by the processors and mother board manufacturers. Saving energy is a complex architectural problem, requiring coordination in terms of optimizing operational processes and facilities design. Lead-tin solder is very malleable making it an ideal shock absorber. The replacement solders have not shown the same amount of reliability in real-world applications. Replacements like tin/copper/silver alloy require higher melting temperatures, which can affect a microprocessors life.

4.4 Sustainability as a Strategy

 A commitment to have a sustainable technology strategy is required for IT. Sustainability can be reuse in IT, reduce complexity levels, Optimize business goals and reduce expenditure. Sustainability in organizations is a two step process. First step is defining the impacts on Business units and activities, impact on Customers with metrics. Second step is to ensure a sustainable solution in Technologies and Processes as a strategy. Data centers are the hungriest energy consumers since they demand larger solutions. Physical servers have drastically increased very recently. Strategizing Reduced energy consumption with reduced operational costs is the main sustainability factor. Reducing power supply also reduces the gas emissions, thus helping the environment. The existing infrastructure can be decomposed tier-wise for finer focus. Each tier like Client, Presentation, Business, and Resource should be analyzed to identify sustainable practices Virtualization is a great factor for sustainability, specially in data centre's where   virtualization is replacing stand-alone physical servers with many virtual server software. IBM, in its Project Big Green [8] has replaced approximately 2,900 individual servers with about 30 mainframe computers to achieve an expected 80 per cent energy saving. Organization should have measurements on quality metrics in every part of architecture and the appropriate solutions to reduce the environmental impacts. Environmental monitoring to measure consumption and actionable metrics and forecasting based on the output should be made a compulsory Green Metrics for large IT Organizations like ISO, SEI-CMM to maintain sustainability.

4.5 Dematerialization

Dematerialization is the replacement of physical items or services with pure digital equivalents. Dematerialization reduces the physical transport of goods saving significant natural resources. For example getting news on mobile releases less carbon dioxide in the environment compared the amount of carbon dioxide released while printing a hardcopy of a newspaper. Computer applications also help dematerialization in a big way. Meetings in companies with video conferences are sources for high resource efficiency. Such meetings impact by reduction in the number of business trips and thus make a significant impact on the environmental energy savings. According to Intel's white paper "existing and implemented use of flexible work indicates that 10 million 'flexi workers' in Europe could save more than 11 million tons of [carbon dioxide] emissions through office space and commuting savings. Thirty million flexi workers could save more than 34 million tons" (Intel, 2007: p.7).

4.6 Extendable Architecture

 The architecture should consider environmental impact and compulsorily be extensible in terms of communication architecture. New technologies to reduce complexity should be used while normalizing existing architectures. Organizations can have a common interface model for metering and reporting energy usage. The environmental parameters or metrics should be compulsorily made a part of Configuration management A focused set of system stock keeping units (SKUs) can enforce energy efficiency and environmental impact standards.

4.7 Material Decomposition

Plastic is moldable, colorful with a very low cost. That major disadvantage of plastic is waste disposal, since plastic items can take 50 to 100 years to degrade. Scientists are experimenting alternatives to plastics from non-petroleum source. The Material disposition in terms of recycling needs to be defined and followed in a better way. UK introduced the Waste Electrical and Electronic Equipment (WEEE)

Regulations with the aim to reduce the quantity of waste from electrical and electronic equipment at the same time increase its re-use, recovery or recycling. The WEEE restrictions forced manufacturers to recycle products and IT departments for disposing computer equipment. Every country produces millions of tons in garbage every year with plastics that take hundreds of years to break down. Companies are coming up with new biodegradable products made from organic materials capable of natural decomposition within months. "Biodegradable plastics will reduce our reliance on foreign oil, lower our carbon footprint, and could eventually be cheaper than traditional plastics from increasingly expensive and dwindling oil," Brian Mooney, a professor in biochemistry at the University of Missouri [9]. Bio-plastics is the main item in creating eco-friendly technologies. The world's first biodegradable computer, , debuted in Dublin Ireland in 2008 called the iameco, had a frame made from wood pulp. Fujitsu introduced the KBPC PX ECO keyboard and the M440 ECO mouse in 2011, made from Arboform, a by-product of the paper-making process. Nokia launched a range of mobile phones with the outer casing and battery cover made of biodegradable plastic made from corn starch. Thermoplastics made from chicken feathers are mechanically strong and stable in water, but collecting and transporting chicken feathers from poultry farms would be a major issue. The mobile phone industry could build technologically upgradable phones so that the phone users need not discard phones. Due to diminishing advances in hardware and software an upgrade cycle for computers is not required.

5. ENERGY EFFICACY COMPUTING

Consumers are increasingly becoming aware of green technologies and are demanding environmentally friendly products around them. Automakers are addressing consumer needs through better fuel economy and lower emissions. Every industry has started paying a close attention to their power bills. The amount spent on data center power has doubled in the recent past. Many companies are changing to cheaper data center power since data center servers, air conditioning, and networking equipments use a major resource of energy. There are many ways of saving energy specially in IT and ICT like closing down the computer on weekends. The life of a monitor is defined on its usage time and not the on/off cycles. Turning a monitor off when not in use will not harm the monitor. Avoiding print outs of email unless necessary and turning a printer on at the time of print saves energy otherwise in use even if it is in an idling stage. Ensuring power management features are activated and setting the monitor to avoid screen savers minimizes the energy wastage. Using a "paperless" office instead of fax-modems, reviewing a document on the terminal, printing a draft on used paper are some more energy efficacy measures. Using smaller fonts and decreasing the spacing between lines, and using a monitor that is the right size for your requirement, since 14-inch monitors use 40% less energy than their bigger counterparts, can be followed on a day to day basis. A high resolution monitor consumes more energy while an ink-jet printer uses only 10% energy of a laser printer.

6. CONCLUSION

Green Computing is a cost-effective and eco friendly use of technology with increase in investment costs for converting existing infrastructures to green computing as an initiative.

Changes begin with small initiatives and there is a commitment to reduce environmental impact. Organizations are proactively considering environmental resource constraints with IT goals. IT architects are adopting sustainability in their data center system design. New technology which is efficiency driven has to monitored on environmental quality metrics. The metrics need to be built into all levels of the infrastructure. Green technology itself is a goal to provide society's energy by non-damage of natural resources. This can be achieved by creating fully recyclable products, reducing pollution and inventing new and alternative technologies that benefit the environment. Energy intensive manufacturing can be made more energy efficient. Petroleum filled plastics can be replaced with bioplastics or plant-based polymers. The dumping of old computers can be avoided by upgrading and repairing in time existing systems. Power consuming components can be replaced with lesser power hungry parts and toxic materials like lead can be replaced by silver and copper making recycling of computers more effective. Though the performance of application of computers is increasing, the awareness of the cost and scarcity of the energy required to power them is also on the rise.

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