

Green Computing

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ABSTRACT

Green computing or sustainability is not simply the operational energy consumption of computing equipment. Green computing must take the product life cycle into consideration, from production to operation to recycling. This study focuses on the production and the operation phases of the product life cycle and demonstrates what actions will result in overall carbon footprint reduction for personal and business computing under various operational conditions and environments. Energy consumption related to end-of-life product recycling is not discussed in this study and is not believed to have a significant impact on the validity of the sustainability analysis based on production and operation energy consumption and carbon footprint.

Keywords: *Energy Conservation, Energy Consumption, Performance Appliances, Recycling, Solid State Circuits.*

1. INTRODUCTION

It is widely known and accepted that computers - and IT in general - greatly contribute to global warming. Through energy consumption, irresponsible disposal of hardware lacking biodegradability, and use of hazardous materials, corporate Information Technology departments are definite sources of environmental destruction.

Green computing is a new paradigm of designing the computer system which considers not only the processing performance but also the energy efficiency. Power management is one of the approaches in green computing to reduce the power consumption in distributed computing system. This assignment is to ensure that the cost due to power consumption and network transportation is minimized. The performance of the system is extensively evaluated.

2. Literature Survey

2.1 Green Computing

Green Computing is a recent trend towards designing, building, and operating computer systems to be energy efficient. While programs such as Energy Star have been around since the early 1990s, recent concerns regarding global

climate change and the energy crisis have led to renewed interest in Green Computing. Data centers are significant consumers of energy - both to power the computers as well as to provide the necessary cooling. This paper proposes a new approach to reduce energy utilization in data centers. In particular, our approach relies on consolidating services dynamically onto a subset of the available servers and temporarily shutting down servers in order to conserve energy. We present initial work on a probabilistic service dispatch algorithm that aims at minimizing the number of running servers such that they suffice for meeting the quality of service required by service-level agreements. Given the estimated energy consumption and projected growth in data centers, the proposed effort has the potential to positively impact energy consumption.



2.2 FIVE Steps to Green Computing

(a). **Develop a sustainable green computing plan.** Discuss with your business leaders the elements that should be factored into such a plan, including

organizational policies and checklists. Such a plan should include recycling policies, recommendations for disposal of used equipment, government guidelines and recommendations for purchasing green computer equipment. Green computing best practices and policies should cover power usage, reduction of paper consumption, as well as recommendations for new equipment and recycling old machines. Organizational policies should include communication and implementation.

(b). Recycle. 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. Never discard computers in a landfill. Recycle them instead through manufacturer programs such as HP's Planet Partners recycling service or recycling facilities in your community. Or donate still-working computers to a non-profit agency.

(c). Make environmentally sound purchase decisions. Purchase Electronic Product Environmental Assessment Tool registered products. EPEAT is a procurement tool promoted by the nonprofit Green Electronics Council to:

- Help institutional purchasers evaluate, compare and select desktop computers, notebooks and monitors based on environmental attributes.
- Provide a clear, consistent set of performance criteria for the design of products.
- Recognize manufacturer efforts to reduce the environmental impact of products by reducing or eliminating environmentally sensitive materials, designing for longevity and reducing packaging materials.

(d). Reduce Paper Consumption. There are many easy, obvious ways to reduce paper consumption:

E-mail, electronic archiving, use the “track changes” feature in electronic documents, rather than redline corrections on paper. When you do print out documents, make sure to use both sides of the paper, recycle regularly, use smaller fonts and margins, and selectively print required pages.

(e). Conserve energy. Turn off your computer when you know you won't use it for an extended period of time. Turn on power management features during shorter periods of inactivity. Power management allows monitors and computers to enter low-power states when sitting idle. By simply hitting the keyboard or moving the mouse, the computer or monitors awakens from its low power sleep mode in seconds. Power management tactics can save energy and help protect the environment.

2.3 The Phases of the Green IT Life Cycle

The life cycle has distinct phases. Understanding what happens in each phase will dramatically improve the way you manage the negative environmental impact of your computing. The phases of Green IT are

- Mining and Manufacturing ('Build')
- Buying and Using
- Recycling or Disposal

Transportation is also a factor, because it takes place between each phase. Mined materials are transported for refinement and then on to factories. From the factory (perhaps in China, but almost certainly remote from where you are if you're reading this in North America or Western Europe), your newly built computer, phone or tablet is then transported to a warehouse and a retail outlet, and finally to your home.

The Mining & Manufacturing Phase

Different devices use different materials, but one estimate states that a typical PC and monitor contains at least twenty-seven different compound materials and that the semiconductor industry uses more than one thousand hazardous substances. Obviously, energy is consumed in mining and manufacturing which contributes to overall carbon emissions.

But there are other issues: much of the mining and manufacturing is carried out in developing countries. Are workers fairly paid and treated? Are mining practices monitored for their impact on the environment? Are hazardous substances controlled?

This is the most difficult stage of the Green IT life cycle for us, as individual citizens, to really understand and influence. But there *are* things we can do.

I just Googled the name of a well-known computer manufacturer plus 'sustainability policy'. It took me all of thirty seconds to find out that they appear to take their commitments in this area seriously and have policies on:

- Including their suppliers in the environmental strategy
- Minimizing waste and using recyclable materials in manufacture
- Continual assessment of environmental impact

The Buying & Using Phase

Things are more straightforward when it comes to buying and using computers. But there are several issues to consider:

- **Is it the right time to buy new?** New computing devices are becoming more and more energy efficient. There comes a point when it makes sense to invest in a more modern PC or laptop. But remember that when you buy the new device you are also buying its

embedded emissions. If you are running out of storage or processing power, try to prolong the life of your PC by using cloud services such as Drop box, Google Drive or Amazon Cloud Drive.

- **Do I need the biggest and most powerful computer?** This is where cloud computing services come in again. Over the next few years we expect a trend towards smaller, lighter and less powerful computers. Why? Because they can use the processing power and storage of servers and applications that are in the cloud.
- **How can I choose the most energy efficient PC or other device?** There are different standards across the world, but the EPEAT (Electronic Product Environmental Assessment Tool) and Energy star certifications are good places to start for Green IT purposes.
- **How can I operate my computing equipment efficiently?** There are a few good practices you can follow. First, use the power management facility of your PC to make sure you are conserving energy where possible. Second, always switch off computers when in use. After closing down, switch off at the power socket, as most power adaptors (and rechargers) continue to draw power even when the device is switched off or not attached. Also, make sure there is a good air flow where you are working so that less energy is consumed by your device in keeping itself cool.
- **What about energy sources?** An issue that big companies are addressing is the quality (and not just volume) of the energy they use. In the home, this equates to using energy companies committed to sustainable energy generation, or to using your own solar-powered energy generation.

The Recycling or Disposal Stage: A Green IT Challenge

The recycling of computing devices is a potentially massive problem, and is a vitally important Green IT phase. Because many of the materials used are toxic, it's vital that landfill disposal is avoided. In landfills, materials leach into the soil and eventually find their way into water supplies. In the past there have also been problems with dumping computing and other electronic waste in developing countries where it is often dangerously burned or left to pollute water supplies. Here are some options on what to do:

- **Reuse your old computer in your own home.** If your processor and storage aren't up to all the jobs you want it to do, you could use it just for a single task such as word processing or web browsing.
- **Find a new home for your PC.** There are lots of websites that have set up exchange schemes for old PCs. You can also try local schools and charities. On the internet you can find hundreds of organizations who need old PCs or specialize in recycling them.
- **Wipe your data before disposal!** Make sure you have permanently deleted your personal details from your computer before recycling. See this resource for more advice.
- **Use a reputable disposal facility.** If all else fails, find a reputable disposal and recycling facility. Your local authority may have details of how and where you can dispose of electronic equipment.



2.4 Distinctive Features of a Green Computer

Let's now take a look at green computer features-- which will help you in determining whether the computer you're buying is truly green or not. Most computer manufacturers have introduced a series of green PCs, but do investigate the following features to ascertain how green their computers are.

□ **Low Use of Hazardous Elements:** A lot of hazardous substances are used in the production of a computer ranging from the more lethal ones like cadmium, lead, chromium, and mercury to the relatively less hazardous ones like flame retardants, pesticides, and chlorinated plastics. A green computer's components should ideally be completely free of these lethal substances; thus IEEE environmental performance criteria requires the manufacturers of green computers to explicitly declare the percentage composition of these substances on the product. As for the less hazardous substances, the focus is on reduction of their use, since their elimination may not be completely possible.

- **Energy Efficient:** That's one feature of green computers that pleases not just environmental enthusiasts but also the budget-conscious buyer. Every green computer will have an energy star rating on it, and the more the stars the more energy

efficient the computer will be. Some green computers are also available with the option of running them on renewable energy like solar energy, for which the manufacturers will supply you with all the required accessories.

- **Recycled Materials Used for Manufacturing:** A truly green computer will have most of its components, especially the plastic ones, made of recycled materials. And the manufacturers are required to declare what percentage of material used in the production of the computer is recycled, with minimum thresholds specified at 10 percent. However, it's more environmentally friendly to opt for a computer that's built with more than 25 percent of recycled material. Ideally, printed circuit boards are the only things that may not contain recycled material.
- **End of Life Recovery:** The green computers are designed in such a way that at the end of their life their components can be easily reused, disassembled, or recycled. A minimum of 65% of the parts of the computer should be recyclable or reusable. Apparently, some of the better brands of green computers guarantee a minimum of 90% reusable or recyclable parts. Also, the parts that are hazardous should be marked accordingly for easy identification and expert handling.
- **Use of Renewable and Bio-Based Materials:** Another of the important green computer features is the increased use of renewable or bio-based materials. Again a minimum of 10 percent of such materials should have been used in the production of the green computer components, and the same must be declared.
- **Longer Product Life:** Green computers come in modular and upgradeable

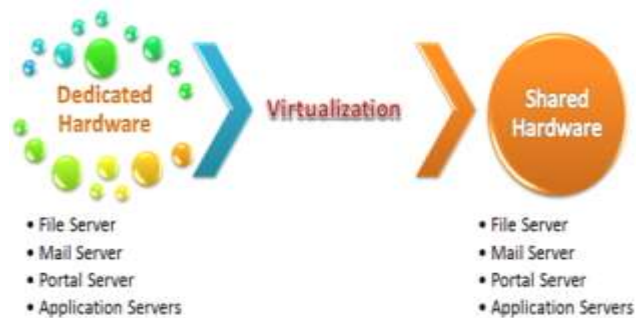
designs with the idea of extending their life cycle. The manufacturers are required to provide a minimum of 3 years' warranty or guarantee, and they must also ensure that the replacement parts will be made available to all buyers up to a minimum of five years. That certainly is one more good reason for you to buy a green computer.

- **End of Life Take-back Facility:** Every green computer comes with a take-back policy, wherein the manufacturer provisions to take back the computer at the end of its life and offer the buyer a new purchase at a competitive price. So, do verify that the brand of green computer that you're buying offers a buy-back or take-back.
- **Manufacturer's Certification:** Before you settle on a particular brand of green computers, you must ensure that its manufacturer has ISO-14001 certification, which is the bare minimum for a manufacturer to qualify as environmental-policy compliant.
- **Packaging Material:** What's a green computer that comes in a toxic or non-recyclable packaging? Truly, it isn't one! So, do check the packaging material details to see that the material used is completely non-toxic and at least 90% of it is recyclable. It will be even better if the packaging is made of recycled material.

2.5 Approaches to green computing

Virtualization: Computer virtualization is the process of running two or more logical computer systems on one set of physical hardware. The concept originated with the IBM mainframe operating systems of the 1960s, but was commercialized for x86-compatible computers only in the 1990s. With virtualization, a system administrator could combine several physical systems into virtual machines on one single, powerful system, thereby unplugging the original hardware and reducing power and cooling

consumption. Several commercial companies and open-source projects now offer software packages to enable a transition to virtual computing. Intel Corporation and AMD have also built proprietary virtualization enhancements to the x86 instruction set into each of their CPU product lines, in order to facilitate virtualized computing.



One of the primary goals of almost all forms of virtualization is making the most efficient use of available system resources. With energy and power costs increasing as the size of IT infrastructures grow, holding expenses to a minimum is quickly becoming a top priority for many IT pros. Virtualization has helped in that respect by allowing organizations to consolidate their servers onto fewer pieces of hardware, which can result in sizable cost savings. The datacenter is where virtualization can have the greatest impact, and it's there where many of the largest companies in the virtualization space are investing their resources.

Virtualization also fits in very nicely with the idea of "Green Computing"; by consolidating servers and maximizing CPU processing power on other servers, you are cutting costs (saving money) and taking less of a toll on our environment. Storage virtualization uses hardware and software to break the link between an application, application component, system service or whole stack of software and the storage subsystem. This allows the storage to be located just about anywhere, on just about any type of device, replicated for performance

reasons, replicated for reliability reasons or for any combination of the above.

2.6 Ways of implementation

Power management software's help the computers to sleep or hibernate when not in use. Reversible computing (which also includes quantum computing) promises to reduce power consumption by a factor of several thousand, but such systems are still very much in the laboratories. Reversible computing includes any computational process that is (at least to some close approximation) reversible, i.e., time-invertible, meaning that a time-reversed version of the process could exist within the same general dynamical framework as the original process. Reversible computing efficient use of heat could make it possible to come up with 3-D chip designs, Bennett said. This would push all of the circuitry closer together and ultimately increase performance.

The best way to recycle a computer, however, is to keep it and upgrade it. Further, it is important to design computers which can be powered with low power obtained from non-conventional energy sources like solar energy, pedaling a bike, turning a hand-crank etc.

New Internet Protocol-enabled networks now allow for network integration along the entire supply chain – from generation, transmission, to end-use and metering – and create the opportunity for Intelligent Utility Networks (IUN) which applies sensors and other technologies to sense and respond in real-time to changes throughout the supply chain. The IP-enabled network connects all parts of the utility grid equipment, control systems, applications, and employees. It also enables automatic data collection and storage from across the utility based on a common information model and service-oriented architecture (SOA), which enables a flexible use of information technology. This in turn allows utilities to continuously analyze data so that they can better manage assets and operations.



Electronics giants are about to roll out eco-friendly range of computers (like desktops and laptops) that aim at reducing the e-waste in the environment. Besides desktops and laptops, other electronic hardware products should also be strictly adhering to the restricted use of hazardous substances. In other words, they should be free of hazardous materials such as brominated flame retardants, PVCs and heavy metals such as lead, cadmium and mercury, which are commonly used in computer manufacturing. Reliability about the use of green materials in computer is perhaps the biggest single challenge facing the electronics industry. Lead-tin solder in use today is very malleable making it an ideal shock absorber. So far, more brittle replacement solders have yet to show the same reliability in arduous real-world applications.

1. Energy-intensive manufacturing of computer parts can be minimized by making manufacturing process more energy efficient by replacing petroleum filled plastic with bioplastics—plant-based polymers— require less oil and energy to produce than traditional plastics with a challenge to keep these bioplastic computers cool so that electronics won't melt them.

2. Power-sucking displays can be replaced with green light displays made of OLEDs, or organic light-emitting diodes.

3. Use of toxic materials like lead can be replaced by silver and copper.

4. Making recycling of computers (which is expensive and time consuming at present) more effective by recycling computer parts separately with an option of reuse or resale.

5. Future computers could knock 10 percent off their energy use just by replacing hard drives with solid-state, or flash, memory, which has no watt-hungry moving parts.

6. Buy and use a low power desktop or a laptop computer (40-90 watts) rather a higher power desktop (e.g. 300 watts).

7. The maximum power supply (up to 1kW in some modern gaming PCs) is not as important as the normal operating power, but note that power supply efficiency generally peaks at about 50-75% load.

8. Idle state represents 69 to 97% of total annual energy use, even if power management is enabled.

9. Computer power supplies are generally about 70–75% efficient; to produce 75 W of DC output they require 100 W of AC input and dissipate the remaining 25 W in heat.

10. Higher-quality power supplies can be over 80% efficient; higher energy efficiency uses less power directly, and requires less power to cool as well.

11. Thin clients can use only 4 to 8 watts of power at the desktop as the processing is done by a server.

12. For desktops, buy a low power central processing unit (CPU). This reduces both power consumption and cooling requirements.

2.7 Why is Green Computing required?

- Computer consumes a lot of energy,
- Printing often unnecessary stuff is waste,

- Reduce pollution,
- Toxicity.

2.8 Green Manufacturing

- Bamboo: is becoming increasingly popular for making casings for computers and peripherals.
- Recyclable Plastics: computers are constructed from non-recyclable plastics recyclable polycarbonate resin.
- Eco-friendly flame retardant: there are flame retardant silicone compounds available that are flame retardant and completely non-toxic.
- Inventory Management: reducing the quantity of both hazardous materials used in the process and the amount of excess raw materials.
- Volume Reduction: removes hazardous portion of waste from non hazardous portion.

2.9 HISTORY

- It is originated in 1992 at the U.S Environmental Protection Agency that launched Energy Star Program.
- Shortly after that the term “Green Computing” was coined.
- Shortly after that the Swedish also launched the TCO Certification.



3. RESULTS AND DISCUSSIONS

Organizations all over the world are beginning to understand their corporate social responsibility toward the environment. Most companies now believe in conserving energy and power and using environmentally friendly products that help in reducing their carbon footprint. In fact, in many organizations, the need for green computing is put at the top of the agenda. Nowadays, it is imperative for all sized organizations to implement aspects of green computing in their daily workings.

Organizations must follow these simple steps for creating the green computing awareness in their workplaces.

- Announcing green intentions to all employees.
- Setting up a committee to form a green IT plan.
- Centralization of all desktops.
- Using efficient computer applications.
- Power management tactics.
- Business performance enhancement.

4. CONCLUSION

The adoption of green technology in computing has received considerable interest in recent years as more and more companies realize that going green is in their best interest, both in terms of public relations and reduced costs.

Manufacturer's today aim to improve energy efficiency by creating designs that minimize power waste and reduce emissions. Companies reduce the amount of toxic waste materials in the manufacturing process by using recyclable materials and offering to recycle old products.

The application of solutions such as IP video solutions to reduce in-person meetings, the increased use of Wi-Fi and Wi-Max networks and

other such initiatives are still in their nascent stages of development and further improvements in such green technology initiatives will help conserve the world's precious resources in a much better way. The application of green technology in computing has come a long way since its inception in the

early 1990s. An analysis of the history of green computing however indicates that the concept is still in its nascent stage and has a long way to go.

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