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GREENCOMPUTING

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ABTRACT

Green computing or **green IT**, refers to environmentally sustainable computing or IT. In the article *Harnessing Green IT: Principles and Practices*, San Murugesan defines the field of green computing as "the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems such as monitors, printers, storage devices, and networking and communications systems efficiently and effectively with minimal or no impact on the environment." The goals of green computing are similar to green chemistry; reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime, and promote or biodegradability of defunct products and factory waste. Research continues into key areas such as making the use of computers as energy-efficient as possible, and designing algorithms and systems for efficiency-related computer technologies.

INTRODUCTION

"Greening" your computing equipment is a low-risk way for your business to not only help the environment but also reduce costs. It's also one of the largest growing trends in business today.

"Making a conscious decision to go green in the workplace, not only improves your bottom line, but also reduces your carbon footprint. It's a win-win no matter how you look at it", The average PC wastes about half the energy provided to it, according to the Climate Savers Computing Initiative, an industry group dedicated to reducing greenhouse-gas emissions. You should encourage employees to shut down their PCs or put them into sleep mode when not working on them. Nesbitt recommends implementing thin clients produced by Neoware to reduce the TCO of your company's computing environment. (Neoware is a member of www.thegreengrid.org).

PATHWAY TO GREEN COMPUTING

To comprehensively and effectively address the environmental impacts of computing/IT, we must adopt a holistic approach and make the entire IT lifecycle greener by addressing environmental sustainability along the following four complementary paths:

- **Green use** — reducing the energy consumption of computers and other information systems as well as using them in an environmentally sound manner
- **Green disposal** — refurbishing and reusing old computers and properly recycling unwanted computers and other electronic equipment
- **Green design** —computers, servers, cooling equipment, and data centers
- **Green manufacturing** — manufacturing electronic components, computers, and other associated subsystems with minimal impact on the environment.

REUSING AND RECYCLING

Simple Network Consulting receives hundreds of spent printer toner and ink jet cartridges and batteries a year. Instead of tossing these in the garbage, they can be recycled, saving resources and reducing pollution and solid waste. To recycle spent toner or ink jet cartridges (printer and some fax), computers, printers, peripherals,

radios, cell phones, networking equipment, and displays call Simple Network Consulting at 608.446.4464. Improper disposal of computers and electronics is illegal! Consult with your local city/state officials to find out how you can help save the planet from harmful pollutants found in computers, and monitors. Recycling your old equipment is another important action to take. Companies such as Cascade Asset Management recover the most value from your slightly used surplus equipment, provide the secure destruction of your electronic media, or haul away your old computers for environmentally responsible recycling.

REDUCING PAPER WASTE

Rather than creating a paperless office, computer use has vastly increased paper consumption and paper waste.

Here are some suggestions for reducing waste: o Print as little as possible. Review and modify documents on the screen and use print preview.

Minimize the number of hard copies and paper drafts you make.

- Instead of printing, save information to disk.
- Recycle waste paper.
- Buy and use recycled paper in your printers and copiers. From an environmental point of view,
- Do not print out un-necessary e-mail messages.
- Use e-mail instead of faxes or send faxes directly from your computer to eliminate the need for a
- Paper copy.
- Before recycling paper, which has print on only one side, set it aside for use as scrap paper or
- For printing drafts.
- When general information-type documents must be shared within an office, try circulating them
- Instead of making an individual copy for each person. This can also be done easily by e-mail.

While you're waiting to replace your more expensive equipment, you can reduce paper use by printing double-sided pages, and you can purchase refillable printer-ink cartridges. Small steps, but taken in large measure, can lead to a cleaner planet.

TOTAL COST OF OWNERSHIP:

CD monitor prices have been decreasing in recent years. When the total cost of ownership is considered including savings in power consumption and lifespan-LCDs are now less expensive than many CRTs. "Utilizing thin client computing alternatives such as Neoware, thin client devices afford you a multi tiered approach on saving both money on the initial hardware, energy savings, and longer lasting hardware since there are no moving parts.", states Nesbitt referring to the thin client computing devices provided by Neoware.

REGULATIONS AND INDUSTRY INITIATIVES

The Organization for Economic Co-operation and Development (OECD) has published a survey of over 90 government and industry initiatives on "Green ICTs", i.e. information and communication technologies, the environment and climate change. The report concludes that initiatives tend to concentrate on the greening ICTs themselves rather than on their actual implementation to tackle global warming and environmental degradation. In general, only 20% of initiatives have measurable targets, with government programs tending to include targets more frequently than business associations.

GOVERNMENT

Many governmental agencies have continued to implement standards and regulations that encourage green computing. The Energy Star program was revised in October 2006 to include stricter efficiency requirements for computer equipment, along with a tiered ranking system for approved products.

Some efforts place responsibility on the manufacturer to dispose of the equipment themselves after it is no longer needed; this is called the extended producer responsibility model. The European Union's directives 2002/95/EC (Restriction of Hazardous Substances Directive), on the reduction of

hazardous substances, and 2002/96/EC (Waste Electrical and Electronic Equipment Directive) on waste electrical and electronic equipment required the substitution of heavy metals and flame retardants like Polybrominated biphenyl and Polybrominated diphenyl ethers in all electronic equipment put on the market starting on July 1, 2006. The directives placed responsibility on manufacturers for the gathering and recycling of old equipment.

There are currently 26 US States that have established state-wide recycling programs for obsolete computers and consumer electronics equipment. The statutes either impose an "advance recovery fee" for each unit sold at retail, or require the manufacturers to reclaim the equipment at disposal.

INDUDTRY

Climate Savers Computing Initiative (CSCI) is an effort to reduce the electric power consumption of PCs in active and inactive states. The CSCI provides a catalog of green products from its member organizations, and information for reducing PC power consumption. It was started on 2007-06-12. The name stems from the World Wildlife Fund's Climate Savers program, which was launched in 1999.The WWF is also a member of the Computing Initiative.
The Green Electronics Council offers the Electronic Product Environmental Assessment Tool (EPEAT) to assist in the purchase of "green" computing systems. The Council evaluates computing equipment on 28 criteria that measure a product's efficiency and sustainability attributes. On 2007-01-24, President George W. Bush issued Executive Order 13423, which requires all United States Federal agencies to use EPEAT when purchasing computer systems.

The Green Grid is a global consortium dedicated to advancing energy efficiency in data centers and business computing ecosystems. It was founded in February 2007 by several key companies in the industry . The Green Grid has since grown to hundreds of members, including end users and government organizations, all focused on improving data center efficiency.
The Green500 list rates supercomputers by energy efficiency (megaflops/watt, encouraging a focus on efficiency rather than absolute performance.

Green Computing Challenge is an organization that promotes the development of energy conservation technology and practices in the field of Information and Communications Technology (ICT). Green Computing Challenge achieved worldwide notoriety in 2007, when it enlisted as one of the challengers in the 33rd edition of the America's Cup, an effort meant to show how researchers, technologists and entrepreneurs from around the world can be brought together by an exciting vision: building the ultimate renewable energy machine, a competitive America's Cup boat.

APPROACHES FOR GREEN COMPUTING

In the article *Harnessing Green IT: Principles and Practices*, San Murugesan defines the field of green computing as "the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment. "Murugesan lays out four paths along which he believes the environmental affects of computing should be addressed: Green use, green disposal, green design, and green manufacturing.
Modern IT systems rely upon a complicated mix of people, networks and hardware; as such, a green computing initiative must cover all of these areas as well. A solution may also need to address end user satisfaction, management restructuring, regulatory compliance, and return on investment (ROI). There are also considerable fiscal motivations for companies to take control of their own power consumption; "of the power management tools available, one of the most powerful may still be simple, plain, common sense."[13]

Product longevity Gartner maintains that the PC manufacturing process accounts for 70 % of the natural resources used in the life cycle of a PC. Therefore, the biggest contribution to green computing usually is to prolong the equipment's lifetime. Another report from Gartner recommends to "Look for product longevity, including upgradability and modularity." For

instance, manufacturing a new PC makes a far bigger ecological footprint than manufacturing a new RAM module to upgrade an existing one, a common upgrade that saves the user having to purchase a new computer.

ALGORITHMIC EFFICIENCY

The efficiency of algorithms has an impact on the amount of computer resources required for any given computing function and there are many efficiency trade-offs in writing programs. As computers have become more numerous and the cost of hardware has declined relative to the cost of energy, the energy efficiency and environmental impact of computing systems and programs has received increased attention. A study by Alex Wissner-Gross, a physicist at Harvard, estimated that the average Google search released 7 grams of carbon dioxide (CO_2). However, Google disputes this figure, arguing instead that a typical search produces only 0.2 grams of CO_2.

VIRTUALIZATION

Computer virtualization refers to the abstraction of computer resources, such as 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.

TERMINAL SERVICES

Terminal servers have also been used in green computing. When using the system, users at a terminal connect to a central server; all of the actual computing is done on the server, but the end user experiences the operating system on the terminal. These can be combined with thin clients, which use up to 1/8 the amount of energy of a normal workstation, resulting in a decrease of energy costs and consumption. There has been an increase in using terminal services with thin clients to create virtual labs. Examples of terminal server software include Terminal Services for Windows and the Linux Terminal Server Project (LTSP) for the Linux operating system.

POWER MANAGEMENT

The Advanced Configuration and Power Interface (ACPI), an open industry standard, allows an operating system to directly control the power-saving aspects of its underlying hardware. This allows a system to automatically turn off components such as monitors and hard drives after set periods of inactivity. In addition, a system may hibernate, where most components (including the CPU and the system RAM) are turned off. ACPI is a successor to an earlier Intel-Microsoft standard called Advanced Power Management, which allows a computer's BIOS to control power management functions. Some programs allow the user to manually adjust the voltages supplied to the CPU, which reduces both the amount of heat produced and electricity consumed. This process is called undervolting. Some CPUs can automatically undervolt the processor depending on the workload; this technology is called "SpeedStep" on Intel processors, "PowerNow!"/"Cool'n'Quiet" on AMD chips, LongHaul on VIA CPUs,and LongRunwit h Transmeta processors.

OPERATING SYSTEM SUPPORT

The dominant desktop operating system, Microsoft Windows, has included limited PC power management features since Windows 95.These initially provided for stand-by (suspend-to-RAM) and a monitor low power state. Further iterations of Windows added hibernate (suspend-to-disk) and support for the ACPI standard. Windows 2000 was the first NT based operation system to include power management. This required major changes to the underlying operating system architecture and a

new hardware driver model. Windows 2000 also introduced Group Policy, a technology which allowed administrators to centrally configure most Windows features. However, power management was not one of those features. This is probably because the power management settings design relied upon a connected set of per-user and per-machine binary registry values, effectively leaving it up to each user to configure their own power management settings.
This approach, which is not compatible with Windows Group Policy, was repeated in Windows XP. The reasons for this design decision by Microsoft are not known, and it has resulted in heavy criticism Microsoft significantly improved this in Windows Vista by redesigning the power management system to allow basic configuration by Group Policy. The support offered is limited to a single per-computer policy. The most recent release, Windows 7 retains these limitations but does include refinements for more efficient user of operating system timers, processor power management, and display panel brightness. The most significant change in Windows 7 is in the user experience. The prominence of the default High Performance power plan has been reduced with the aim of encouraging users to save power.
There is a significant market in third-party PC power management software offering features beyond those present in the Windows operating system.

POWER SUPPLY

Desktop computer power supplies (PSUs) are generally 70–75% efficient, dissipating the remaining energy as heat. An industry initiative called 80 PLUS certifies PSUs that are at least 80% efficient; typically these models are drop-in replacements for older, less efficient PSUs of the same form factor. As of July 20, 2007, all new Energy Star 4.0-certified desktop PSUs must be at least 80% efficient.

STORAGE

Smaller form factor (e.g. 2.5 inch) hard disk drives often consume less power per gigabyte than physically larger drives. Unlike hard disk drives, solid-state drives store data in flash memory or DRAM. With no moving parts, power consumption may be reduced somewhat for low capacity flash based devices. In a recent case study, Fusion-io, manufacturers of the world's fastest Solid State Storage devices, managed to reduce the carbon footprint and operating costs of MySpace data centers by 80% while increasing performance speeds beyond that which had been attainable via multiple hard disk drives in Raid 0. In response, MySpace was able to permanently retire several of their servers, including all their heavy-load servers, further reducing their carbon footprint.

As hard drive prices have fallen, storage farms have tended to increase in capacity to make more data available online. This includes archival and backup data that would formerly have been saved on tape or other offline storage. The increase in online storage has increased power consumption. Reducing the power consumed by large storage arrays, while still providing the benefits of online storage, is a subject of ongoing research.

VIDEO CARD

A fast GPU may be the largest power consumer in a computer. Energy efficient display options include: No video card - use a shared terminal, shared thin client, or desktop sharing software if display required. Use motherboard video output typically low 3D performance and low power.

DISPLAY

LCD monitors typically use a cold-cathode fluorescent bulb to provide light for the display. Some newer displays use an array of light-emitting diodes (LEDs) in place of the fluorescent bulb, which reduces the amount of electricity used by the display.

TELECOMPUTING

Teleconferencing and telepresence technologies are often implemented in green computing initiatives. The advantages are many; increased worker satisfaction, reduction of greenhouse gas emissions related to travel, and increased profit margins as a result of lower overhead costs for office space, heat, lighting, etc. The savings are significant; the average annual energy consumption for U.S. office buildings is over 23 kilowatt hours per square foot, with heat, air conditioning and lighting accounting for 70% of

all energy consumed. Other related initiatives, such as hostelling, reduce the square footage per employee as workers reserve space only when they need it. Many types of jobs, such as sales, consulting, and field service, integrate well with this technique.

Voice over IP (VoIP) reduces the telephony wiring infrastructure by sharing the existing Ethernet copper. VoIP and phone extension mobility also made hot desking more practical.

CONCLUSIONS

We need computing and networking environments that support many forms of accountability, but we also need to understand how to construct systems with interfaces simple enough to be usable, yet capable of supporting the kinds of security policies we employ intuitively every day.

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