Sustainable Computing: Principles, Trends, Future Directions

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Abstract – This paper presents the concept deployed in sustainable computing and companies. Why sustainable computing is having a deep impact on our life will be justified only when the true need of eco friendly computers will be justified by users themselves. Until then various standards and measures which are defining green computing must be incorporated in all the companies working in it. This paper also presents the future research directions in this field which are slowly gaining significance by reducing overall investment cost and also optimizing operational budget.

Index Terms – Green Sustainable, Power, Energy, Environment

1. INTRODUCTION

Sustainable computing is a principle that addresses a range of policies, procedures, programs and attitudes that run along the length and breadth of any use of information technologies. It is an efficient approach that stretches from power to waste to purchasing to education and is considered as a life-cycle management approach to the deployment of IT across an organization. The concept of Sustainable Computing considers total cost of ownership, the total impact, and the total benefit of technology systems. It is rapidly expanding research area spanning the fields of computer science and engineering, electrical engineering and other engineering disciplines.

The Sustainable IT debate has long focused on reducing the energy consumption of power-hungry systems in large data centers; however, businesses are now realizing that reducing energy consumption during the operation of assets is only part of the story. Manufacturing, distribution, and disposal of systems also require energy and contribute to the carbon footprint. Today, attention is turning toward a broader approach to reducing an organization's IT-related environmental footprint that also takes into account the entire lifecycle of IT equipment including acquisition, utilization, and retirement.

The first step toward the Sustainable computing movement was the commencement of the Energy Star program in 1992. This served as a voluntary label that was awarded to computer products that were successful in proving that they used minimum energy while maximizing efficiency. The rating was awarded to monitors, refrigerators, television sets, air conditioners and other household appliances. One of the first results of green computing was the Sleep mode function of computer monitors which places a consumer's electronic equipment in standby mode when a pre-set period of time passes when user activity is not detected.

2. CURRENT ENERGY PERSPECTIVES IN 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. Its environmentally friendly products are manufactured using a range of clean-computing strategies, and the company is striving to educate markets on the benefits of green computing for the sake of the environment, as well as productivity and overall user experience.

One of the VIA Technologies' ideas is to reduce the "carbon footprint" of users — the amount of greenhouse gases produced, measured in units of carbon dioxide (CO2). Greenhouse gases naturally blanket the Earth and are responsible for its more or less stable temperature. The emissions are mainly a result of fossil-fuel-burning power plants. (In the United States, such electricity generation is responsible for 38 percent of the country's carbon dioxide emissions.)

VIA aims to offer the world's first PC products certified carbon free, taking responsibility for the amounts of CO2 they emit. The company works with environmental experts to calculate the electricity used by the device over its lifetime, generally three years. From this data, one can conclude how much carbon dioxide the device will emit into the atmosphere

during its operation. This estimate will serve as an indicator, and the company will pay regional organizations for the "sequestering," or offsetting, of the emissions. Offsetting carbon dioxide can be achieved in different ways. One way is to plant trees that absorb CO2 as they grow, in the region in which the processors were purchased. The necessary amount of trees per processor is represented by VIA's TreeMark rating system.

In addition, VIA promotes the use of such alternative energy sources as solar power, so power plants wouldn't need to burn as much fossil fuels, reducing the amount of energy used. Wetlands also provide a great service in sequestering some of the carbon dioxide emitted into the atmosphere. Although they make up only 4 to 6 percent of the Earth's landmass, wetlands are capable of absorbing 20 to 25 percent of the atmospheric carbon dioxide. VIA is working closely with organizations responsible for preserving wetlands and other natural habitats, and others who support extensive recycling programs for ICT equipment. The amount paid to these organizations will be represented by a proportion of the carbon-free product's price.

Carbon-emissions control has been a key issue for many companies who have expressed a firm commitment to sustainability. Dell is a good example of a company with a green image, known for its free worldwide product-recycling program. Dell's Plant a Tree for Me project allows customers to offset their carbon emissions by paying an extra $2 to $4, depending on the product purchased. AMD, a global microprocessor manufacturer, is also working toward reducing energy consumption in its products, cutting back on hazardous waste and reducing its eco-impact. The company's use of silicon-on-insulator (SOI) technology in its manufacturing, and strained silicon capping films on transistors, have contributed to reduced power consumption in its products.

Amid the international race toward alternative-energy sources, VIA is setting its eyes on the sun, and the company's Solar Computing initiative is a important part of its green-computing projects. For that purpose, VIA partnered with Motech Industries, one of the largest producers of solar cells worldwide. Solar cells fit VIA's power-efficient silicon, platform, and system technologies and enable the company to develop fully solar-powered devices that are nonpolluting, silent, and highly reliable. Solar cells require very little maintenance throughout their lifetime, and once initial installation costs are covered, they provide energy at virtually no cost. Worldwide production of solar cells has increased rapidly over the last few years; and as more governments begin to recognize the benefits of solar power, and the development of photovoltaic technologies goes on, costs are expected to continue to decline. As part of VIA's "pc-1" initiative, the company established the first-ever solar-powered cyber community center in the South Pacific, powered entirely by solar technology.

In February 2003, the European Union adopted the Restriction of Hazardous Substances Directive (RoHS). The legislation restricts the use of six hazardous materials in the manufacture of various types of electronic and electrical equipment. The directive is closely linked with the Waste Electrical and Electronic Equipment Directive (WEEE), which sets collection, recycling, and recovery targets for electrical goods and is part of a legislative initiative that aims to reduce the huge amounts of toxic e-waste**.** Driven by these directives, VIA implemented a set of internal regulations in order to develop products that are compliant with these accepted policies, including the use of nonhazardous materials in its production of chipsets, processors, and companion chips. In 2001, they focused on lead-free manufacturing, introducing the Enhanced Ball Grid Array (EBGA) package for power efficient VIA processors and the Heat Sink Ball Grid Array (HSBGA) package for their chipsets. In traditional manufacturing processes, lead is used to attach the silicon core to the inside of the package and to facilitate integration onto the motherboard through tiny solder balls on the underside of the package. VIA's lead-free manufacturing technologies do not require a lead bead, and the solder balls now consist of a tin, silver, and copper composite.

However, not everyone is satisfied with this new objective. Howard Johnson of the online *EDN* magazine says that the move toward lead-free devices is not only unhelpful but actually worse for the environment. "The additional tin mining required to produce high-purity tin alloys, plus the mining of other precious metals required to alloy with tin in substitution for lead, is a poor trade for the use of existing lead, much of which comes from recycled products," Johnson writes. He also believes that lead-free assembly is less reliable than lead-based assembly, partially due to the increased growth of tin whiskers — small, hair-like metallic growths that naturally emerge from the surface of solid tin. On lead-free tin surfaces, these whiskers can grow to a length sufficient to short an electronic circuit to another, leading to product failure.

A central goal of VIA's green-computing initiative is the development of energy-efficient platforms for low-power, small-form-factor (SFF) computing devices. In 2005, the company introduced the VIA C7-M and VIA C7 processors that have a maximum power consumption of 20W at 2.0GHz and an average power consumption of 1W. These energy-efficient processors produce over four times less carbon during their operation and can be efficiently embedded in solar-powered devices.

VIA isn't the only company to address environmental concerns: Intel, the world's largest semiconductor maker, revealed eco-friendly products at a recent conference in

London. The company uses virtualization software, a technique that enables Intel to combine several physical systems into a virtual machine that runs on a single, powerful base system, thus importantly reducing power consumption. Earlier this year, Intel joined Google, Microsoft, and other companies in the launch of the Climate Savers Computing Initiative that commits businesses to meet the Environmental Protection Agency's Energy Star guidelines for energy-efficient devices.

Kevin Fisher, Intel's EU standards director, says that while the company is dedicated to its green-computing plans, it is important to not blame the IT industry alone for carbon emissions worldwide. He argues that the industry also helps in saving huge amounts of power due to the Internet, enabling, for example, online shopping and billing.

Green technology is gaining more and more public attention through the work of environmental organizations and government initiatives. VIA is one of the first corporations to concentrate on green computing that seems less a passing trend than a first step toward important changes in technology. In May 2007, IBM unveiled its Project Big Green, dedicated to increasing energy efficiency across the company's branches around the world. Experts say that businesses will continue to invest in clean computing, not only because of future regulations, policies, and social demands to reduce their carbon footprint, but also due to the important long-term savings it can make.

Several companies are already headfirst into the green-computing business. Located in the Silicon Valley and founded in 2006, Zonbu was the first company to introduce a completely environmentally responsible computer – Their "Zonbox" computer is a carbon-emission neutral computer, thanks to a low-power design and regulatory-grade carbon offsets. The device, which complies both to Energy Star standards and the Restriction of Hazardous Substances Directive (RoHS), consumes only 15W, compared to the 175W consumed by a typical desktop PC. Another American company, Everex, has released the Impact GC3502, a green PC that uses 20W of power, owing to a 1.5GHz VIA C7-D processor. Several companies are already headfirst into the green-computing business. Located in the Silicon Valley and founded in 2006, Zonbu was the first company to introduce a completely environmentally responsible computer – Their "Zonbox" computer is a carbon-emission neutral computer, thanks to a low-power design and regulatory-grade carbon offsets. The device, which complies both with Energy Star standards and the Restriction of Hazardous Substances Directive (RoHS), consumes only 15W, compared to the 175W consumed by a typical desktop PC. Zonbu also provides a free take-back program to minimize environmental e-waste.

3. PROBLEMS FACED AT PRESENT

On the design side, ensuring energy efficiency in IC chips requires a keen focus on reducing voltage, while retaining performance and enabling our signature rich-feature integration within ever-smaller packages. This is not a simple process and demands high levels of skilled engineering, which is why, to this day, we can offer the lowest power-consuming embedded, notebook, and desktop processors in the world.

Achieving such high levels of energy efficiency and low heat production also allows us to build smaller, which in turn allows our partners to build smaller systems, providing savings for consumers not only in terms of power requirements but also in disposal costs. For portable systems, such as the new generation of ultra-mobile devices, this also means longer battery life, an essential element of ultra-mobility. Other companies cannot achieve this, as their chips consume too much power and emit too much heat.

On the manufacturing side, the removal of hazardous substances raises several technical challenges, especially the replacement of lead as a stable solder substance. However, an aggressive approach to the problem, starting five to six years ago, allowed our engineers the time to experiment with effective replacement alloys, so that our processor platforms were effectively manufactured lead-free long before the industry was mandated to do so.

4. FUTURE DIRECTIONS OF SUSTAINABLE COMPUTING

The plan towards sustainable IT should include new electronic products and services with optimum efficiency and all possible options towards energy savings. That is enterprise wise companies are laying emphasis on moving towards Eco Friendly Components in Computers, the use of eco-friendly sustainable components will become the norm rather than the exception failure. The future green technology holds big advancements in shaping energy efficient computers.

The new Energy Star 4.0 specifications include the 80 PLUS standards that encourage manufacturers to deploy power supplies that convert at least 80 percent of the electricity from the wall outlet to actual computing power.

Intel's Core 2 Duo processor heralds a new era in green computing. This processor draws power only for the parts of the chip actually in use. Marvell's processor chip uses power factor correction (PFC) to determine the amount of power any given application requires and uses this information to optimize power usage for maximum efficiency.

Such power-saving technologies are poised to become the norm in the future, and further advancements will bring forth more break through. The development of nanotechnology also translates to greater energy efficiency. The future Nano

computer chip would be three or four levels of magnitude smaller in size and considerably faster than the ones currently available .Another revolutionary idea that could find breakthrough in the future is harnessing the power needed for the computer to operate from keystrokes, mouse movements, and the light from the monitor.VIA aims to offer the world's first carbon free computers. Such "carbon free" computers emit greenhouse gasses, but the manufacturers offset such "carbon footprint" or the amount of greenhouse gas emitted by the computer during its lifetime through many ways such as planting trees. The move toward carbon free computing may also take the shape of the development of solar energy cells. VIA's "PC-1" initiative aims to not just power the computer entirely through solar cells, but also use solar energy exclusively in its manufacturing process. Toward this end, it has launched the world's first ever solar-powered cyber community center in the South Pacific, powered entirely by solar technology.

The thrust toward carbon free computing also takes the shape of developing green power sources with zero carbon emissions. Recent developments suggest the possibility of incorporating renewable energy technologies into structures in creative and unexpected ways.

- Sybarithe's Dice House, a 9 x 9 meter cube that sits on an octagonal plinth is a successful prototype of a carbon free unit. A large thermoplastic umbrella on the garden roof shades and insulates the house and collects solar energy.
- Kennedy and Voilich Architecture's Soft House harvests energy through solar-energy-collecting textiles hung in the home like curtains. These thin-film photovoltaic textiles generate nearly 16,000 watt-hours of electricity a day.
- A house museum in Ulricehamn Sweden proposed a revolutionary concept of the using the body heat of visitors and the equipment located inside the building to supply the building's heat. Solar cells on the roof provide part of the energy to run electrical equipment and heat water.

5. CONCLUSION

Although it may seem tough, the task of greening a company's IT infrastructure life cycle and in particular its asset disposition practices should be simple to implement while the rewards and payoffs can be positive. In the IT sector, adopting rules and practices that contribute to reaching the company's environmental, social and security targets should also lead to substantial gains for the company's bottom line, while securing vital assets and protecting brand image. When designing these practices, companies should ensure that overall guidelines listed in this white paper are met, or at least addressed and discussed with their selected service providers. Failure to address these key issues could lead to substandard practices that may drag down the organization's effort to reduce its carbon footprint and document it properly.

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