GREEN COMPUTING

A SEMINAR REPORT

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Bonafide Certificate

Certified that this seminar report titled "**GREEN COMPUTING**" is the bonafide work done by **Ajoy P Mathew** who carried out the work under my supervision.

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Ajoy P Mathew

Abstract

Green computing is the study and practice of using computing resources efficiently. The goals are similar to green chemistry; that is reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime, and promote recyclability or biodegradability of defunct products and factory waste. Taking into consideration the popular use of information technology industry, it has to lead a revolution of sorts by turning green in a manner no industry has ever done before. It is worth emphasizing that this “green technology” should not be just about sound bytes to impress activists but concrete action and organizational policy. Opportunities lie in green technology like never before in history and organizations are seeing it as a way to create new profit centers while trying to help the environmental cause. The plan towards green IT should include new electronic products and services with optimum efficiency and all possible options towards energy savings.

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1. Introduction

Green computing is the study and practice of using computing resources efficiently. The primary objective of such a program is to account for the triple bottom line, an expanded spectrum of values and criteria for measuring organizational (and societal) success. The goals are similar to green chemistry; reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime, and promote recyclability or biodegradability of defunct products and factory waste.

Modern IT systems rely upon a complicated mix of people, networks and hardware; as such, a green computing initiative must be systemic in nature, and address increasingly sophisticated problems. Elements of such as solution may comprise items such as end user satisfaction, management restructuring, regulatory compliance, disposal of electronic waste, telecommuting, virtualization of server resources, energy use, thin client solutions, and return on investment (ROI).

As 21st century belongs to computers, gizmos and electronic items, energy issues will get a serious ring in the coming days, as the public debate on carbon emissions, global warming and climate change gets hotter. Taking into consideration the popular use of information technology industry, it has to lead a revolution of sorts by turning green in a manner no industry has ever done before.

2. Approaches to Green Computing

2.1 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.

In the past, it was necessary for each computer system to have its own storage to function. Storage virtualization makes it possible for systems to access a shared storage subsystem that is somewhere out on the net. It also means that copies of data that used to be stored on every computer's disks can now be stored once in the shared storage subsystem. It's clear that this approach would reduce the number of storage devices needed, the amount of power required, the heat produced and, as a wonderful side effect, would reduce the operational and administrative costs of back up, archival storage and the like.

Since the link between the application and the actual storage device is broken by storage virtualization software, the device can be selected based upon what's most appropriate. Applications and data that are accessed frequently can be stored on high speed, expensive devices that consume more power. Applications and data that are accessed less frequently can be stored on lower speed, less expensive devices that consume less power. Rarely accessed applications and data can be migrated to archival storage devices that result in the lowest cost and require the lowest power consumption.

2.2 Power Management:

Power management for computer systems are desired for many reasons, particularly:

- Prolong battery life for portable and embedded systems.
- Reduce cooling requirements.
- Reduce noise.
- Reduce operating costs for energy and cooling.

- Lower power consumption also means lower heat dissipation, which increases system stability, and less energy use, which saves money and reduces the impact on the environment.
- 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 LongRun with Transmeta processors.

The power management for microprocessors can be done over the whole processor, or in specific areas.With dynamic voltage scaling and dynamic frequency scaling, the CPU core voltage, clock rate, or both, can be altered to decrease power consumption at the price of slower performance. This is sometimes done in real time to optimize the power-performance tradeoff.

Examples:

- Intel SpeedStep
- AMD Cool'n'Quiet
- AMD PowerNow!
- VIA LongHaul (PowerSaver)
- Transmeta LongRun and LongRun2

Newer Intel Core processors support ultra-fine power control over the function units within the processors.

2.3 Power Supply:

Power supplies in most computers (PSUs for short) aren't designed for energy efficiency. In fact, most computers drain more power than they need during normal operation, leading to higher electrical bills and a more dire environmental impact.

The 80 Plus program is a voluntary certification system for power-supply manufacturers. The term "80 Plus" is a little complicated, so bear with me for a moment. If a PSU meets the certification, it will use only the power it needs at a given load: In other words, it won't use more power than it needs. For example, if your PC requires only 20 percent of the total power of a 500-watt PSU, the system will consume no more than 100 watts. Only when the PC requires full power will the PSU run at the full wattage load. An 80 Plus power supply can save about 85 kilowatt hours per PC, per year. In many ways, it's the heart of a green PC, since it manages the power for all the other components. It also has the most dramatic effect on your energy bill. Of course, all 80 Plus power supplies are also lead-free and RoHS compliant.

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. Various initiatives are underway to improve the efficiency of computer power supplies. Climate savers computing initiative promotes energy saving and reduction of greenhouse gas emissions by encouraging development and use of more efficient power supplies

2.4 Storage:

There are three routes available, all of which vary in cost, performance, and capacity.

The most conventional route is the the 3.5" desktop hard drive. Recently, major drive manufacturers have begun to focus on reduced power consumption, resulting in such features as the reduced RPM low-power idle mode with fixed rotation speed for reduced power consumption. The advantages of this route are the highest possible capacity, the best performance (out of the highest-end solid-state drives).

The second option, which also lends itself to affordability, is to use a 2.5" laptop hard drive. These consume less power than larger disks as a result of their smaller platters, smaller motors, and firmware that is already optimized for power consumption versus most 3.5" harddisks. With capacities up to 320GB, reasonable capacity is well within reach, although the price is substantially higher than an equivalent 3.5" disk. With a green system aimed at light use, a 120GB or 160GB laptop drive is a very affordable, lower-power alternative to a 3.5" disk.

The lowest-power option is to use a solid state hard drive (SSD), which typically draw less than one-third the power of a 2.5" disk. The latest, highest-performance SSDs are very fast but extremely expensive, and currently top out at only 64GB. That's adequate for light use, but wholly inadequate for gamers, video editing, and other heavy uses. More affordable SSDs are available in larger capacities, but are not cheap and typically have slow write performance, which limits their practical utility.

Smaller form factor (e.g. 2.5 inch) hard disk drives often consume less power 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. Even at modest sizes, DRAM based SSDs may use more power than hard disks, (e.g., 4GB i-RAM uses more power and space than laptop drives). Flash based drives are generally slower for writing than hard disks.

2.5 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.
- Reuse an older video card that uses little power; many do not require heatsinks or fans.
- Select a GPU based on average wattage or performance per watt

The easiest way to conserve power is to go with integrated video. This is the lowest-performance option, but for office users, casual browsing, and pure 2D use, it's more than adequate—and well worth saving the 10W, 20W, or even 35W from a discrete video card. Motherboards spitting out integrated video via DVI or HDMI aren't that hard to find, so power-users with their massive LCDs don't have to suffer.

2.6 Displays:

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. LCD monitors uses three times less when active, and ten times less energy when in sleep mode. LCDs are up to 66% more energy efficient than CRTs, LCDs are also upwards of 80% smaller in size and weight, leading to fuel savings in shipping. LCDs produce less heat, meaning you'll need less AC to keep cool.LCD screens are also easier on the eyes. Their lower intensity and steady light pattern result in less fatigue versus CRTs.

A newer LCD draws 40-60W maximum in a modest 19", 20", or 22" size. That number grows close to 85W or 100W maximum for a 24" unit. Drop them down to standby or turn them off entirely when not using them to minimize power consumption. By comparison, a 21" CRT typically uses more than 120W, more than double the power of a typical 22" LCD.

2.7 Materials Recycling:

Computer recycling refers to recycling or reuse of a computer or electronic waste. This can include finding another use for the system (i. e. donated to charity), or having the system dismantled in a manner that allows for the safe extraction of the constituent materials for reuse in other products. Additionally, parts from outdated systems may be salvaged and recycled through certain retail outlets and municipal or private recycling centers.

Recycling computing equipment can keep harmful materials such as lead, mercury, and hexavalent chromium out of landfills, but often computers gathered through recycling drives are shipped to developing countries where environmental standards are less strict than in North America and Europe. The Silicon Valley Toxics Coalition estimates that 80% of the post-consumer e-waste collected for recycling is shipped abroad to countries such as China, India, and Pakistan. Computing supplies, such as printer cartridges, paper, and batteries may be recycled as well.

Obsolete computers are a valuable source for secondary raw materials, if treated properly, however if not treated properly they are a major source of toxins and carcinogens. Rapid technology change, low initial cost and even planned obsolescence have resulted in a fast growing problem around the globe. Technical solutions are available but in most cases a legal framework, a collection system, logistics and other services need to be implemented before a technical solution can be applied. Electronic devices, including audio-visual components (televisions, VCRs, stereo equipment), mobile phones and other hand-held devices, and computer components, contain valuable elements and substances suitable for reclamation, including lead, copper, and gold. They also contain a plethora of toxic substances, such as dioxins, PCBs, cadmium, chromium, radioactive isotopes, and mercury. Additionally, the processing required to reclaim the precious substances (including incineration and acid treatments) release, generate and synthesize further toxic by-products

Most major computer manufacturers offer some form of recycling, often as a free replacement service when purchasing a new PC. At the user's request they may mail in their old computer, or arrange for pickup from the manufacturer. Individuals looking for environmentally-friendly ways in which to dispose of electronics can find corporate electronic take-back and recycling programs across the country. Open to the public (in most cases), corporations nationwide have begun to offer low-cost to no-cost recycling, and have opened centers nationally and in some cases internationally. Such programs frequently offer services to take-back and recycle electronics including mobile phones, laptop and desktop computers, digital cameras, and home and auto electronics. Companies offer what are called “take-back” programs that provide monetary incentives for recyclable and/or working technologies.

While there are several health hazards when it comes to dealing with computer recycling some of the substances you should be aware of:

- Lead common in CRTs, older solder, some batteries and to some formulations of PVC. Can be harmful if not disposed of properly.
- Mercury in fluorescent tubes. With new technologies arising the elimination of mercury in many new model computers is taking place.
- Cadmium in some rechargeable batteries. It can be hazardous to your skin if exposed for too long. Although many people are exposed to it everyday it just depends on the amount of exposure.
- Liquid crystals are another health hazard that should be taken into consideration although they do not have the nearly the same effects as the other chemicals

Businesses seeking a cost-effective way to responsibly recycle large amounts of computer equipment face a more complicated process. They also have the option of contacting the manufacturers and arranging recycling options. However, in cases where the computer equipment comes from a wide variety of manufacturers, it may be more efficient to hire a third-party contractor to handle the recycling arrangements. There exist companies that specialize in corporate computer disposal services both offer disposal and recycling services in compliance with local laws and regulations. Such companies frequently also offer secure data elimination services.

2.8 Telecommuting:

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 hotelling, reduce the square footage per employee as workers reserve space only when they need it. Many types of jobs -- sales, consulting, and field service -- integrate well with this technique.

Rather than traveling great distances, in order to have a face-face meeting, it is now possible to teleconference instead, using a multiway video phone. Each member of the meeting, or each party, can see every other member on a screen or screens, and can talk to them as if they were in the same room. This brings enormous time and cost benefits, as well as a reduced impact on the environment by lessening the need for travel - a damaging source of carbon emissions.

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

3. Future of Green Computing

As 21st century belongs to computers, gizmos and electronic items, energy issues will get a serious ring in the coming days, as the public debate on carbon emissions, global warming and climate change gets hotter. If we think computers are nonpolluting and consume very little energy we need to think again. It is estimated that out of $250 billion per year spent on powering computers worldwide only about 15% of that power is spent computing- the rest is wasted idling. Thus, energy saved on computer hardware and computing will equate tonnes of carbon emissions saved per year. Taking into consideration the popular use of information technology industry, it has to lead a revolution of sorts by turning green in a manner no industry has ever done before. Opportunities lie in green technology like never before in history and organizations are seeing it as a way to create new profit centers while trying to help the environmental cause. The plan towards green IT should include new electronic products and services with optimum efficiency and all possible options towards energy savings. Faster processors historically use more power. Inefficient CPU's are a double hit because they both use too much power themselves and their waste heat increases air conditioning needs, especially in server farms--between the computers and the HVAC. The waste heat also causes reliability problems, as CPU's crash much more often at higher temperatures. Many people have been working for years to slice this inefficiency out of computers. Similarly, power supplies are notoriously bad, generally as little as 47% efficient. And since everything in a computer runs off the power supply, nothing can be efficient without a good power supply. Recent inventions of power supply are helping fix this by running at 80% efficiency or better.

4. Ways of implementation

Power management softwares 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's 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.

The electric utility industry is in an unprecedented era of change to meet increasing customer demand for greater reliability and different services in the face of substantial regulation and volatile energy costs. This requires new approaches and business models to allow greater network reliability, efficiency, flexibility and transparency. At the same time, the utility industry is digitizing, transforming from an electromechanical environment to a digitized one.

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.

- 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.

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

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

- 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.
- 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.
- Buy and use a low power desktop or a laptop computer (40-90 watts) rather a higher power desktop (e.g. 300 watts).
- Find out the normal operating power (watts) required.
- 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.
- Idle state represents 69 to 97% of total annual energy use, even if power management is enabled.
- 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.
- Higher-quality power supplies can be over 80% efficient; higher energy efficiency uses less power directly, and requires less power to cool as well. As of 2007, 93% efficient power supplies are available.
- Thin clients can use only 4 to 8 watts of power at the desktop as the processing is done by a server.
- For desktops, buy a low power central processing unit (CPU). This reduces both power consumption and cooling requirements.
- Buy hardware from manufacturers that have a hardware recycling scheme, and recycle your old computer equipment rather than sending it to landfill.
- Turn your computer and monitor off when you are not using it.
- Enable hibernation using the power management settings. Standby does not save as much power.

- Replace your CRT screen with an LCD screen.
- Keep your PC or laptop for at least 5 years. If you're leasing, shift to a 5 year period. This reduces resource and energy consumption associated with the manufacture and distribution of PCs by 40%, compared to replacing PCs every 3 years which is current corporate practice.
- Avoid an unnecessary operating system version upgrade which requires a hardware upgrade.
- Use Linux (such as Ubuntu), which requires less resources than many other operating systems on an older computer as a spare or a file server.
- Use server virtualization to aggregate multiple under-utilized servers onto more energy efficient server infrastructure.
- Use blade servers instead of rack or standalone servers to reduce power consumption.
- Specify low energy consumption level in Request for Tender documents.
- Measure your data centre power usage.
- Use server and/or web-based applications where possible to extend desktop service life and reduce desktop software maintenance.
- Establish policies governing the acquisition, usage and disposal of computer hardware to minimize energy consumption and environmental impact.

5. GREEN IT: The next burning issue for business

It is becoming widely understood that the way in which we are behaving as a society is environmentally unsustainable, causing irreparable damage to our planet. Rising energy prices, together with government-imposed levies on carbon production, are increasingly impacting on the cost of doing business, making many current business practices economically unsustainable. It is becoming progressively more important for all businesses to act (and to be seen to act) in an environmentally responsible manner, both to fulfill their legal and moral obligations, but also to enhance the brand and to improve corporate image. Companies are competing in an increasingly 'green' market, and must avoid the real and growing financial penalties that are increasingly being levied against carbon production.

IT has a large part to play in all this. With the increasing drive towards centralized mega data centers alongside the huge growth in power hungry blade technologies in some companies, and with a shift to an equally power-hungry distributed architecture in others, the IT function of business is driving an exponential increase in demand for energy, and, along with it, is having to bear the associated cost increases.

The problem:

Rising energy costs will have an impact on all businesses, and all businesses will increasingly be judged according to their environmental credentials, by legislators, customers and shareholders. This won't just affect the obvious, traditionally power-hungry 'smoke-belching' manufacturing and heavy engineering industries, and the power generators. The IT industry is more vulnerable than most – it has sometimes been a reckless and profligate consumer of energy. Development and

Improvements in technology have largely been achieved without regard to energy consumption.

The impact:

Rising energy costs and increasing environmental damage can only become more important issues, politically and economically. They will continue to drive significant increases in the cost of living, and will continue to drive up the cost of doing business. This will make it imperative for businesses to operate as green entities, risking massive and expensive change. Cost and environmental concern will continue to force us away from the ‘dirtiest’ forms of energy (coal/oil), though all of the alternatives are problematic. We may find ourselves facing a greater reliance on gas, which is economically unstable and whose supply is potentially insecure, or at least unreliable.

It may force greater investment in nuclear power, which is unpopular and expensive, and it may lead to a massive growth of intrusive alternative energy infrastructure – including huge wind farms, or the equipment needed to exploit tidal energy. Solving the related problems of rising energy costs and environmental damage will be extremely painful and costly, and those perceived as being responsible will be increasingly expected to shoulder the biggest burden of the cost and blame. It may even prove impossible to reduce the growth in carbon emissions sufficiently to avoid environmental catastrophe. Some believe that the spotlight may increasingly point towards IT as an area to make major energy savings, and some even predict that IT may even become tomorrow’s 4x4/SUV, or aviation – the next big target for the environmental lobby, and the next thing to lose public support/consent.

The solution:

A fresh approach to IT and power is now needed, putting power consumption at the fore in all aspects of IT – from basic hardware design to architectural standards, from bolt-on point solutions to bottom-up infrastructure build. IBM has a real appreciation of the issues, thanks to its size, experience and expertise, and can help its customers to avoid the dozens of ‘wrong ways’ of doing things, by helping to identify the most appropriate solutions. There is a real, economic imperative to change arising now, and it is not just a matter of making gestures simply to improve a company’s environmental credentials.

The cost of power:

The whole topic of energy consumption is gaining increased prominence in Western Europe as a consequence of rising energy prices, and as a result of a growing focus on global warming and the environment.

A history – and the future – of increasing power consumption:

Many of today’s motor cars and car engines are increasingly poorly suited to today’s demand for economy and fuel efficiency, having been designed when oil prices were low and when performance, space and comfort were the most important design drivers. Each new car model since the Model T was therefore designed to out-perform its predecessors. Only now is fuel economy and environmental ‘friendliness’ becoming more important than speed and horsepower. The situation is similar in the IT industry, which has seen a concentration on processing power and storage capacity, while power consumption has been ignored. As in the automotive industry, energy consumption was regarded as being much less important than performance.

The IT industry has seen a concentration on processing power and storage capacity, while power consumption has been ignored. As manufacturers competed to create ever-faster processors, smaller and smaller transistors (running hotter and consuming more electricity) were used to form the basis of each new generation of processors. Increased operating temperatures added to the consumption of power, requiring more

and more cooling fans. Modern IT systems provide more computing power per unit of energy (kWh) and thus reduce energy consumption per unit of

computing power. Despite this, they are actually responsible for an overall increase in energy consumption, and for an increase in the cost of energy as a proportion of IT costs. This is because users are not simply using the same amount of computing power as before, while using the new technology to reduce their power consumption (or operating temperatures), nor are they using technology to leverage savings in energy costs or in CO2 production.

Instead, users are taking and using the increased computing power offered by modern systems. New software in particular is devouring more and more power every year. Some software requires almost constant access to the hard drive, draining power much more rapidly than previous packages did. Tests of the initial version of Microsoft Windows Vista indicated that it consumed 25% more power than today's Windows XP, for example. The advent of faster, smaller chips has also allowed manufacturers to produce smaller, stackable and rackable servers allowing greater computing power to be brought to bear (and often shoe-horned into smaller spaces) but with no reduction in overall energy consumption, and often with a much greater requirement for cooling.

Despite the trend towards server virtualization and consolidation in some companies, business demand for IT services is increasing, and many companies are still expanding their data centers, while the number of servers in such data centers is still increasing annually by about 18%.While the growth in demand for energy did slow down in 2005 (going from a 4.4% rise to just 2.7%, globally) and though the demand for energy actually fell in the USA, the International Energy Agency has predicted that the world will need 60% more energy by 2030 than it does today.

Data Centers:

In many companies, there has been a shift away from dedicated data centers, as part of an attempt to provide all IT requirements by using smaller boxes within the office environment. Many have found this solution too expensive, experiencing a higher net spend on staff as well as with higher support costs. Energy consumption of distributed IT environments is difficult to audit, but some have also noted a progressive increase in power consumption with the move from centralized to decentralized, then to distributed architecture, and finally to mobility-based computing.

Even where distributed computing remains dominant, the problems of escalating energy prices and environmental concerns are present, albeit at a lower order of magnitude than in the data centre environment, and even though the problems are rather more diffuse and more difficult to solve. Some analysts believe that there is already a trend away from distributed computing back to the data centre, with consolidation and centralization on the rise again. Within a data centre/server environment, technological improvement is driving requirements for greater energy into the building, for increased floor area and for increased cooling capacity.

This may be counter-intuitive, since the emergence of blade servers superficially promised to allow the more efficient use of data centre floor space, by packing more high-performance servers into a single rack. However, this increase in computing power and server numbers for a given floor area multiplies cooling problems, since air is an inefficient media for cooling computers and empty space alone is insufficient to give adequate cooling. Air conditioning and other cooling techniques are required to keep temperatures in check. A typical 1980s server could be cooled quite easily, but though a modern server takes up much less floor space, it is more difficult to cool, and requires more space around it. Though it will require less power per unit of computing power, its overall energy requirement will be considerably higher, and the need for improved cooling will further increase energy requirements – and environmental impact, of course. Analysts recently suggested that by the end of 2008, 50% of the data centers would not have enough power to meet the power and cooling requirements of the new equipment used in high-density server environments.

The new systems are more compact and of higher density, and can call for more localized power and cooling than will typically be found in an existing data centre environment. A blade server system set up in a single rack, can easily weigh more than a tonne, and can in theory call for more than 30kW of power – more than 10 times what would have been required a few years ago. According to Sun Microsystems engineers, a typical rack of servers installed in data centers just two years ago might have consumed a modest 2kW of power while producing 40 watts of heat per square foot. Newer, high-density racks, expected to be in use by the end of the decade, could easily consume as much as 25kW and give off as much as 500 watts of heat per square foot. The energy consumed by fans, pumps and other cooling components already accounts for some 60-70% of the total energy consumption in the data centre, and Gartner predicts that energy costs will become the second highest cost in 70% of the world's data centers by 2009, trailing staff/personnel costs, but well ahead of the cost of the IT hardware.

It is now believed that in most data centers, particularly those located in single-story industrial-type buildings, electrical costs are already more than two to three times greater than real-estate costs, and many existing data centre buildings may be physically incapable of providing the higher levels of power and cooling that are now required. Because IT equipment is usually depreciated every two to three years, investment in new hardware is relatively easy, whereas new data centre equipment (including air conditioning, universal power supplies and generators) are more usually depreciated over 20 years, making new investment more difficult. Investing in new buildings may be more even more problematic. It is thus difficult and costly to build your way out of power consumption and heat problems. The increasing drive toward

Server consolidation in an effort to improve operating costs and operational efficiency is further aggravating the problems of increasing energy consumption, and increased heat generation. Thus, data centre managers must focus on the electrical and cooling issue as never before.

There are cheap, quick-fix, ‘point’ solutions that provide ‘strap-on’ cooling by retrofitting blowers and/or water-cooling systems. Installing water jackets on the server racks allows one to build a much smaller, denser and more efficient data centre. But although liquid cooling is more efficient than air-conditioning, it is still a short-term, stop-gap answer. Much greater efficiencies and greater cost savings can be leveraged by addressing the underlying problem and by using longer-term solutions.

This is likely to entail redesigning and reconfiguring the data centre, however, which obviously requires more long-term investment and a fresh approach to IT, with power consumption at front of mind.

Strategies for change:

The whole purpose of IT is to make businesses more productive and efficient, and to save money. Businesses are competitive bodies, used to having to ‘do more with less’ in order to remain competitive. They will have to learn to use less electricity in just the same way, using green (sustainable) computing to save money. This will demand major changes in IT user behaviours and policies. As energy and infrastructure costs continue to increase exponentially, and as environmental considerations become more prevalent, there is a real need for a power-based IT optimization strategy, bringing power right to the fore of IT policy, thereby impacting the end-toned architecture, hardware and software, and on all of the processes undertaken day-to-day to support a company’s workflow. This could force the adoption of new infrastructure, and will increasingly inform decision making when new platforms are procured, or when decisions are made about IT strategies – whether to centralize or whether to adopt a more distributed architecture and so on. Other companies will have to take more modest steps, simply making sure that desktop PCs, monitors and printers are turned off at night, and/or using more effective power-saving modes on unused equipment. Others will opt to use more energy-efficient components, such as LCDs rather than CRT monitors when buying new hardware.

New dual-core processors are faster than traditional chips and yet use less energy, and the latest generation of dual-core processors (exemplified by Intel's new 'Woodcrest') promise to consume about one third less power than their predecessors while offering up to 80% better performance.

Other IT users may need to investigate the use of DC power. Most energy suppliers provide AC power because it is easier to transport over long distances, although most PCs and servers run on DC, so that the AC current from the utility has to be converted to DC before it reaches the hardware, with inevitable losses of energy in conversion.

Some companies may benefit from moving away from distributed computing based on individual desktop PCs to small, thin client server architecture. It has been suggested that a 10-user system could save about 3,200kWh per year in direct electricity costs (while further energy savings, equivalent to about 11 tonnes of CO_2 per year, would be saved in manufacturing costs). The total production and operating cost savings over the three-year life span of a 10-user system would be more than 33 tonnes.

In an existing server environment, there are significant cost savings associated with any reductions in cooling requirements, and keeping server rooms and computer workspaces at the right temperature is critical.

Virtualization and server consolidation can allow users to ‘do more with less’, allowing one large server to replace several smaller machines. This can reduce the power required and the overall heat produced. By reducing the number of servers in use, users can simplify their IT infrastructure, and reduce the power and cooling requirements. When Dayton, Ohio overhauled its IT infrastructure, replacing a network of 80 archaic terminals and numerous ad hoc PCs with thin clients for 60%

of the staff and PCs for the rest, the city saw a corresponding drop in energy used. The switch saved the city US$700,000 annually from reduced data and software administration expenses, and especially from lower client maintenance costs, with a US$60,000-$90,000 reduction in electricity costs. There is also a corresponding reduction in carbon footprint.

Fortunately, business is getting outside support as it struggles towards greener computing. The US Environmental Protection Agency’s Energy Star programme is already promoting more energy-efficient IT infrastructures and policies, while IBM, Hewlett-Packard, Sun Microsystems and AMD have joined forces to launch the Green Grid environmental lobby, aimed at reducing energy consumption at computer data centers by encouraging and improving power-saving measures.

6. Recent implementations of Green Computing

6.1 Blackle:

Blackle is a search-engine site powered by Google Search. Blackle came into being based on the concept that when a computer screen is white, presenting an empty word page or the Google home page, your computer consumes 74W. When the screen is black it consumes only 59W. Based on this theory if everyone switched from Google to Blackle, mother earth would save 750MW each year. This was a really good implementation of Green Computing.

The principle behind Blackle is based on the fact that the display of different colors consumes different amounts of energy on computer monitors.

6.2 Fit-PC: a tiny PC that draws only 5w:

Fit-PC is the size of a paperback and absolutely silent, yet fit enough to run Windows XP or Linux. fit-PC is designed to fit where a standard PC is too bulky, noisy and power hungry. If you ever wished for a PC to be compact, quiet and green – then fit-PC is the perfect fit for you. Fit-PC draws only 5 Watts, consuming in a day less power than a traditional PC consumes in 1 hour. You can leave fit-PC to work 24/7 without making a dent in your electric bill.

6.3 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 a 1.2 gigahertz processor and 512 meg of RAM. It also contains no moving parts, and does even contain a fan. You can get one for as little as US$99, but it does require you to sign up for a two-year subscription."

6.4 Sunray thin client:

Sun Microsystems is reporting increased customer interest in its Sun Ray, a thin desktop client, as electricity prices climb, according to Subodh Bapat, vice president and chief engineer in the Eco Responsibility office at Sun. Thin clients like the Sun Ray consume far less electricity than conventional desktops, he said. A Sun Ray on a desktop consumes 4 to 8 watts of power, because most of the heavy computation is performed by a server.

Sun says Sunrays are particularly well suited for cost-sensitive environments such as call centers, education, healthcare, service providers, and finance.

PCs have more powerful processors as well as hard drives, something thin clients don't have. Thus, traditional PCs invariably consume a substantially larger amount of power. In the United States, desktops need to consume 50 watts or less in idle mode to qualify for new stringent Energy Star certification.

6.5 The Asus Eee PC and other ultra portables:

The "ultra-portable" class of personal computers is characterized by a small size, fairly low power CPU, compact screen, low cost and innovations such as using flash memory for storage rather than hard drives with spinning platters. These factors combine to enable them to run more efficiently and use less power than a standard form factor laptop. The Asus Eee PC is one example of an ultraportable. It is the size of a paperback, weighs less than a kilogram, has built-in Wi-Fi and uses flash memory instead of a hard drive. It runs Linux too.

7. Conclusion

So far, consumers haven't cared about ecological impact when buying computers, they've cared only about speed and price. But as Moore's Law marches on and computers commoditize, consumers will become pickier about being green. Devices use less and less power while renewable energy gets more and more portable and effective. New green materials are developed every year, and many toxic ones are already being replaced by them. The greenest computer will not miraculously fall from the sky one day, it'll be the product of years of improvements. The features of a green computer of tomorrow would be like: efficiency, manufacturing & materials, recyclability, service model, self-powering, and other trends. Green computer will be one of the major contributions which will break down the 'digital divide', the electronic gulf that separates the information rich from the information poor.

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