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Green Computing – New Paradigm of Energy Efficiency and e-Waste minimization – A Pilot study on current trends

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Abstract: ***With rising energy cost and growing environmental concerns, GREEN COMPUTING is receiving more and more attention. . Software and system architectures (in terms of concurrency patterns) play a crucial role in both computing and telecommunication systems, and they have been analyzed for performance, reliability, maintainability, and security. Yet, little work on analysis based on the amount of energy that the CPU/processor will consume has been reported. Since most communication systems have to run 24/7 (e.g., most server farms, servers in a cloud computing infrastructure), the energy consumption of a system based on a specific software architecture is of great importance. For example, high energy consuming always leads to higher operational cost of the system. High energy consumption also implies more heat produced, thus, more power is required for cooling-down. As the number of computers is increasing day by day, so is the amount of electricity consumed by them which in turn is increasing the carbon content in atmosphere. This problem has been realized by the researchers and several corrective measures are being taken which help in minimizing the power usage of computers and this process is called as Green Computing. In the present paper he authors present several green initiatives currently taken in the computer industry, as well as issues that have been raised regarding these initiatives and presents a study about the green computing and e-waste recycling process. The authors also tried to explore how to maximize energy efficiency during the product's lifetime, and also to promote the recycling redundant products and factory waste .***

Keywords: ***Green Computing; cloud computing; green initiatives; e-waste; sleep and hibernate component***

I. INTRODUCTION

Green computing is the practice of using computing resources efficiently. Modern IT Systems comprises of complicated networks both software and hardware level. Green computing is the utmost requirement to protect environment and save energy along with operational expenses in today's increasingly competitive world. It's also important to study about what kind of energy gains and operational gains can be achieved. Hence, analysis of the gap between what we have today and what we'll have to do is essential in order to achieve the benefits of green computing. It is true that Green Computing can not be implemented in one day but every big change begins from small initiatives. For example a user must set the power option in a computer in economic mode or the computer should go to sleep mode when the user is not using the computer at all. When a user going away from the PC for more than a few minutes then the computer should go to stand-by mode and the monitor should goto stand by mode or it may switch off automatic to save appreciable amount of energy. In recent years, companies in the computer industry have come to realize that going green is in their best interest, both in terms of public relations and reduced costs. In the present paper the authors will take a look at several green initiatives currently under way in the computer industry, as well as issues that have been raised regarding these initiatives. Green computing or green IT, basically concerns to environmentally sustainable computing or IT. The field of green computing is defined as "the knowledge and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—which include printers, monitors, and networking, storage devices and communications system efficiently and effectively with minimal or no impact on

the environment. Green computing is minimizing energy costs and saving the environment . Energy to manufacture, store, operate, and cool computing systems has grown significantly in the recent years, primarily due to the volume of systems and computing that companies now heavily rely upon. Basically, the whole green aspect came about quite a few years back when the news that the environment was not a renewable resource really hit home and people started realizing that they had to do their part to protect the environment. Government sectors across the globe have initiated energy-management programs, such as Energy Star, an international standard for energy-efficient electronic equipment that was created by the United States Environmental Protection Agency in 1992 and has now been adopted by several other countries. Energy Star reduces the amount of energy consumed by a product by automatically switching it into ―sleep mode when not in use or reducing the amount of power used by a product when in ―standby mode. Surprisingly, standby ―leaking, the electricity consumed by appliances when they are switched off, can represent as much as 12 percent of a typical household‘s electricity consumption. Basically, the efficient use of computers and computing is what green computing is all about. The triple bottom line is what is important when it comes to anything green and the same goes for green computing. This considers social responsibility, economic viability and the impact on the environment. Many business simply focus on a bottom line, rather than a green triple bottom line, of economic viability when it comes to computers. The idea is to make the whole process surrounding computers more friendly to the environment, economy, and society. This means manufacturers create computers in a way that reflects the triple bottom line positively. Once computers are sold businesses or people use them in a green way by reducing power usage and disposing of them properly or recycling them. The idea is to make computers from beginning to end a green product. The solution to green computing is to create an efficient system that implements these factors in an environmentally friendly way. A good example would be IT managers purchasing hardware that has been EPEAT approved meaning that maintenance is reduced, the hardware's life is extended, and makes recycling the computer easy once it is no longer necessary. Mobile phones are better than computers – green computing. A computer is used for Surfing Internet, chat, gaming, social networking, downloading, desktop computing including documents, spreadsheets or presentation making or just watching photos and videos. On the other hand a mobile phone is capable of doing all these, rather sometimes more than the traditional phones. The mobile phones have faster processors, more ram, faster wireless Internet connectivity and larger memories. Mobile Phones consume very low power. VIA Technologies, a Taiwanese company that manufactures motherboard chipsets, CPUs, and other computer hardware, introduced its initiative for "green computing” If everyone takes into account green computing then our world of computers will have as little a negative impact on our physical world as possible and that is what green computing is all about. This paper describes need of the green computing and future of the green computing. The primary objective of such a program is to account for the triple efficiently bottom line. In the present world all most every person is using computer. Every office is computerized and every one can use the computer for their own purpose. But most of the users are not aware about the harmful effects of the computers. The computers emit carbon dioxide harmful gases. The energy consumption by various computing devices is also plays a main role towards our harmful environment. In the present paper the authors have made an systematic study on various issues and challenges of green computing and finally how one can implement green computing methodology in educational institution or in commercial environment.

II. WHY GREEN COMPUTING

Climate change and global warming are viewed by many as the two most challenging problems facing the Earth. Green IT and in particular, green computing, are two ways the information and communications technology community is working to address those problems. With the explosive growth of Internet-enabled cloud computing and high-performance computing centers, IT's energy consumption and sustainability impacts are expected to continue climbing well into the future. Efforts are underway in both industry and academia, however, to address it.

As demand for computing and communication continue to grow, servers, networks, and data centers will consume more and more energy. For example, IT resources in the US now consume more than 1.5 per cent of total electricity consumption.

Power consumption of US data centers in 2006 was 1.5 per cent of the total energy consumed, and at a cost of more than US $4.5 billion.

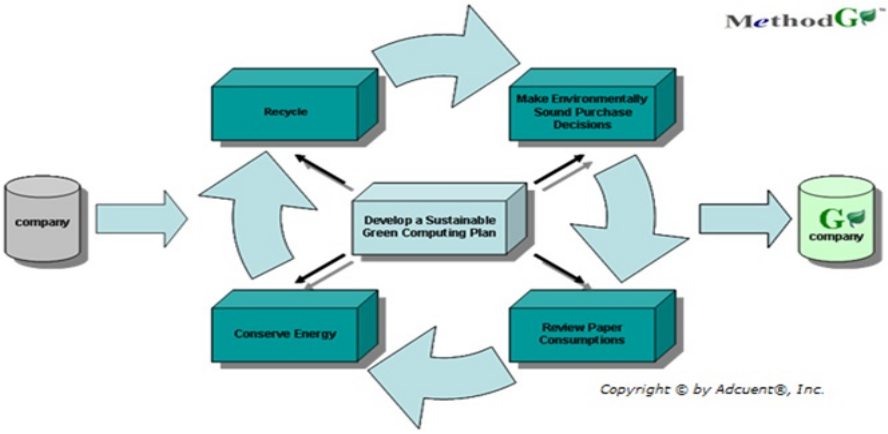

Figure-Implementation of green computing

Today, the green communications concept focuses mainly on developing energy-efficient communication techniques for networks. Three main approaches are suggested for power management in communication networks: do less work, reduce operating speed, and turn off idle elements. Doing less work means optimizing processes so that the system executes fewer operations and thus uses less energy. Decreasing operation speed could prevent redundant resource use from the mismatched speed of sub processes. Finally, shutting down idle network components and links can obviously reduce energy dissipation. The total energy consumption by servers, computers, monitors, data communication requirements and cooling systems for data centres is steadily increasing. This increase in energy consumption results in increased greenhouse gas emissions. Each PC in use generates about a ton of carbon dioxide every year. As energy crisis deepends and the resources deplete, we need to seriously think about making substantial changes in our lifestyle for energy conservation. Green computing is one way of dealing with the energy crisis. It is possible to reduce carbon emissions, save energy and protect the environment as a whole with this approach. Green computing is the practice of using computers and related technology in an environmentally responsible manner. It aims at radically changing the way we go about computing, using the electronic devices and following strict energy conservation guidelines, so as to minimize the damage caused to the environment by computers. This activity is not just limited to saving electricity, but also takes a holistic approach towards environment-friendly use of computers. Devising innovative and environment-conscious techniques for energy generation is also one of its aspects.

III. GREEN COMPUTING TECHNIQUES

Saving power is the main objective of Green Computing and that is also with minimum impact to the environment. It is about how to reduce the power consumption of the monitors to save energy, increase the life time of the product and also to make it efficient. “Faster processors use more power, because they use too much power and their waste heat increases temperature for which air conditioning necessary, especially in server farms--between the computers and the HVAC. 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. Some of the proposed methods are as follow:

III.1. Profiling the Energy Usage

III.1.1 Energy Usage Profile for the Hardware:

The server’s energy consumption is much easier to measure. Several low-cost devices are available to monitor energy consumption. The important thing is to build an overall picture of how much energy the server uses at idle and under stress. The energy usage of individual components does not need to be exact, but is important because it provides a ranking system for

energy consumers within the server. CPU usage is the most expensive resource in terms of actual cost and environmental impact. Memory usage has a minimal cost at best. Hard disk usage has minimal cost. The gist is that if we are going to attempt to optimize our infrastructure and application to minimize energy usage, the CPU should be the primary target.

III.1.2 Energy Usage Profile for the Application:

Tools can be used to determine precise CPU usage for specific components of the application. These tracking statistics can then be used to attack the high cost portions of the application. In other words, find the most expensive operations and optimize them to reduce CPU usage. The ultimate goal is to lower resource usage to the point where multiple applications can be hosted on the same set of servers. Server sharing can reduce the energy footprint of all the applications involved.

III.1.3 Energy Usage Profile for the Operating System:

Looking at the data collected for physical servers when idle and at peak loads, we can see that a significant amount of energy is wasted on the system idle process. This wasted energy can be reclaimed through operating system virtualization. Virtualization allows the host machine to run at approximately 80 percent of peak processor utilization with fractionally increased power requirements. The first step in tuning the virtual guest is to disable or deactivate unneeded services. Depending on the type of guest operating system and its purpose, there may be a number of unnecessary services running by default. Eliminate screensavers and evaluate your event logging requirements for each guest operating system. This will avoid wasted processor cycles and disk activity. Minimizing disk activity is essential to both performance and energy efficiency. Look closely at the network utilization of your applications with a network monitoring tool to locate and eliminate chatty protocols and unnecessary network communication. Wireshark is an effective and freely available tool for network analysis.

III.2. Virtualization

Virtualization, a term that used to the various techniques, methods or approaches to create a virtual environment, such as a virtual hardware platform, virtual operating system (OS), storage device, or network resources.Computer virtualization is the process of running two or more logical computer systems on one set of physical hardware. 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. One of the primary goals of almost all forms of virtualization is making the most efficient use of available system resources. Virtualization highlights the idea of “Green Computing”; by consolidating servers and maximizing CPU processing power on other servers. Storage virtualization makes it possible for systems to access a 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 etc.

III.2.1 Consolidation:

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, theamount 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.

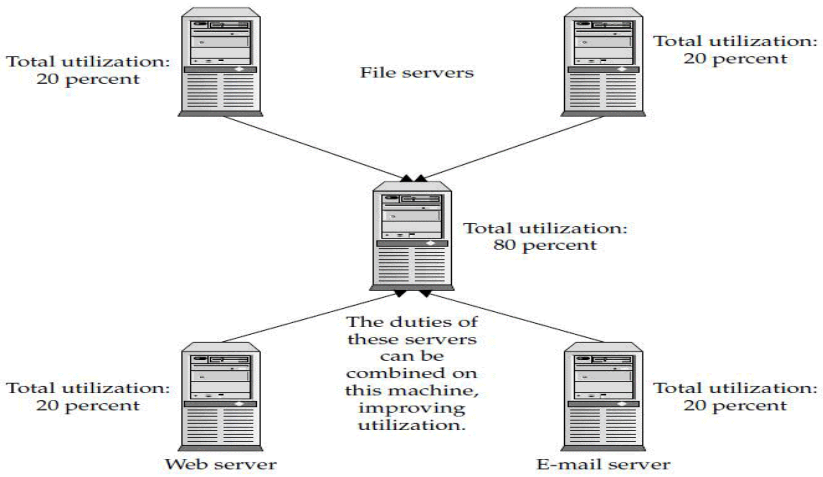

Figure1:-by consolidating servers we can reduce the power and increase s the utilization of machines.

III.2.2 Appropriate devices :

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.

III.3. Conserve energy

Activating the power management features on your computer saves energy and money while helping the environment. Your computer's SLEEP and HIBERNATE settings are two of the most effective ways for you to make your computer more environmentally friendly.

III.3.1 Sleep mode:

Allowing the monitor to fall asleep after idling for some time Period is another easily employed method for improving energy efficiency. When a monitor falls asleep or enters a "stand by "mode, it enters a low power consumption state. It saves 60-70 percent of electricity. The monitor screen will be blank, with no light emitting from it.

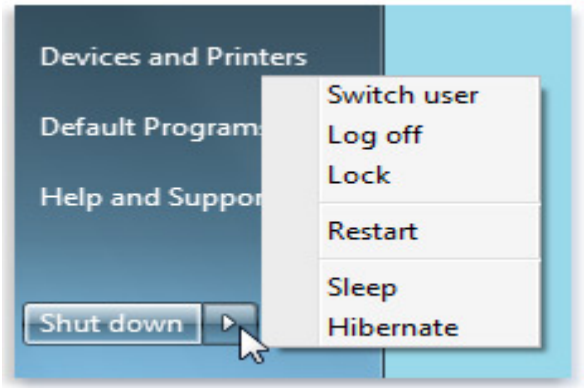

Figure2:-sleep mode functions

III.3.2 Hibernate mode:-

The hibernate mode goes one step further than standby mode by completely powering off the computer. Invoking the hibernate mode causes the memory state to be saved onto the hard disk before powering down. When coming out of hibernate mode, the computer restores the memory state, returning the computer to its pre-hibernate state. A desktop computer will

consume approximately 3 watts in hibernate mode vs. 5 watts for standby A disadvantage of the hibernate mode is that it takes slightly longer to enter and exit hibernate than standby, the result of saving and restoring the memory state to and from the disk.

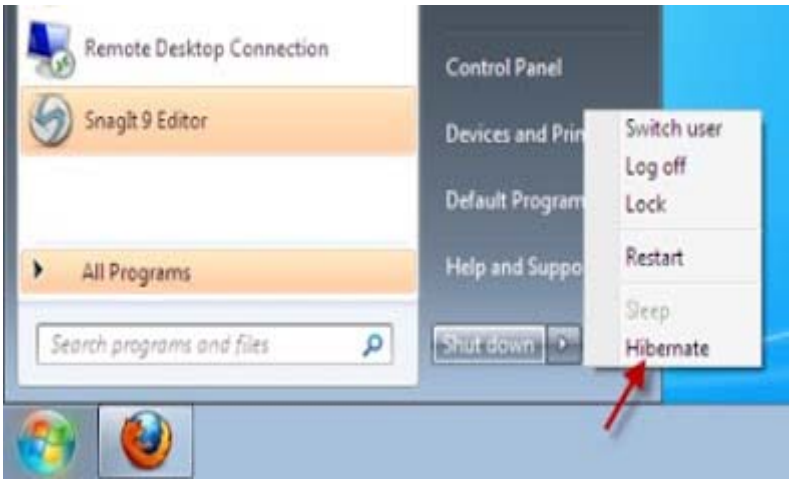

Figure2:-hibernate steps for windows 7.

III.3.3 Screen savers:-

One of the simplest and most familiar power saving methods is the proper use of screen savers. The typical graphical screen saver, originally designed to minimize "burn-in" of computer monitors, actually increases power consumption Rather than using a 3D graphics screen saver, and with screen burn-in no longer a concern, power use easily can be reduced by disabling screen savers. In this way, power consumed by intensive graphics is eliminated, leading to the monitor "falling asleep " after a period of idling, automatically conserving still more power.

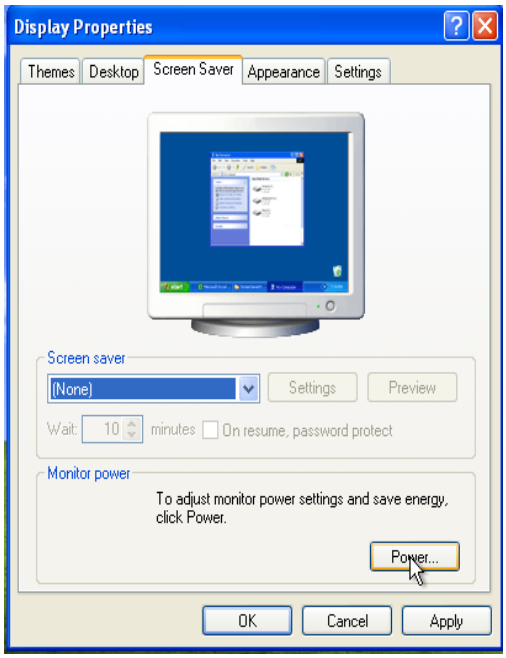

Figure3:-option for no screen saver.

III.3.4 System Standby Mode:

Standby or **Stand by** is a mode the computer, monitor, or other device enters when idle for too long. This mode helps conserve power when a computer or computer device is not in use without having to sacrifice the time it would take to turn off and on the computer. When in Standby, the computer or monitor has a solid of flashing light, indicating that there is still power but the computer is in Standby. To **resume**, **wake**, or **wake up** a computer in Standby mode move the mouse, press a key on the keyboard, or press the power button on the computer without holding it down for more than a few seconds.

Figure4:-computer in standby mode.

IV. DEVELOPING THIN CLIENT DEVICE

This solution would exploit the technology behind a server-client type of system. These devices would be extremely thin and would contain no storage space as well as computing would be kept at a minimum. These are typically specially designed, sealed "black boxes", containing only the firmware and I/O ports required to connect to the monitor, mouse, keyboard, and network. The boxes are designed to exchange only keystrokes, screen refreshes, and mouse clicks with the application residing on the server; the application runs on the server and feeds screen refreshes back to the thin client. The thin client machines not only reduce the cost of the computers but also implements green computing and minimize e-waste..

There would be a huge central server which would be used to communicate many such thin client devices. The entire storage would occur at the server, as well as the computing tasks would be carried out at the server itself. The thin clients would only possess the technologies required to communicate with these central servers and send information to the servers and retrieve information back from them. This would drastically reduce the energy usage and will be limited to only the energy spent by the central server. This solution can be very effective in office networks where currently you would be having for example 100 cabins in one large room, each having a Desktop PC. These 100 PC's can well be replaced by 100 such thin client devices and one central server interacting with them.

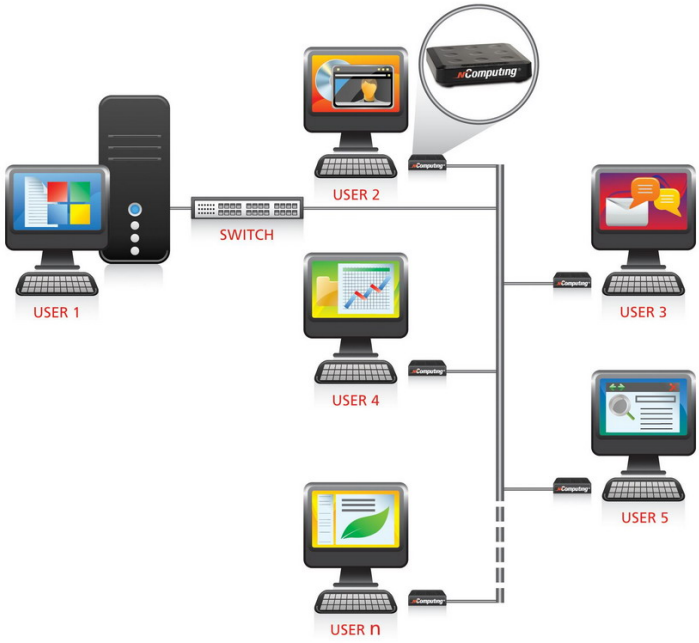

Figure-desktop virtualization using N computing.

The thin client computing model is inherently more secure, since the applications and the computing power are all housed in the data center, with its strict rules and disciplines for change control and application installation and revision. With no disk

access to install applications, transfer data, or introduce malware, thin clients are a perfect fit for any Higher Education Institution's strict security requirements. To make a thin client a fewer components and fewer resources are required. In thin client a reduced number of components require fewer electromechanical connections (solder joints) and fewer mechanical fasteners and adhesives. Thin clients are approximately 60 - 70% lighter in weight and smaller in size than PCs and it directly affects transportation needs and associated CO_2 or greenhouse gas (GHG) emissions. Due to small size of thin client more thin clients can be shipped in the same container, lowering fuel requirements and the environmental impact per unit shipped. Smaller items also require less packaging, which both consumes raw material resources and energy and contributes to generation of solid waste. Since each case is unique, the specific effects of device size on materials usage and shipping impact should be determined through a lifecycle assessment (LCA) study. In addition Desktop virtualization makes computing available to more people within the organization for less cost. Above all it saves a lot of energy and minimizes e waste, thus contributing the sustainability of the environment.

V. Recycle of Electronic Equipment

Discard used or unwanted electronic equipment in a convenient and environmentally responsible manner. Recycling computing equipment can keep harmful materials such as lead, mercury, and hexavalent chromium out of landfills, and can also replace equipment that otherwise would need to be manufactured, saving further energy and emissions. Computer systems that have outlived their particular function can be re-purposed, or donated to various charities and non-profit organizations. However, many charities have recently imposed minimum system requirements for donated equipment. Additionally, parts from outdated systems may be salvaged and recycled through certain retail outlets and municipal or private recycling centers. Computing supplies, such as printer cartridges, paper, and batteries may be recycled as well. A drawback to many of these schemes is that computers gathered through recycling drives are often 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.

VI. E-Waste Minimization

1. By replacing petroleum-filled plastic with bioplastics or plant-based polymers, which require less oil and energy to produce than traditional plastics and developing solutions against a challenge to keep these bioplastic computers cool so that electronics won't melt them.
2. Landfills can be controlled by making best use of the device by upgrading and repairing in time with a need to make such processes (i.e., up gradation and repairing) easier and cheaper.
3. Avoiding the discarding will not only control e-waste out of dumps but also save energy and materials needed for a whole new computer.
4. Power-sucking displays can be replaced with green light displays made of OLEDs, or organic light-emitting diodes.
5. 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 a option of reuse or resale.

VII. Green Initiative

a) Upgrade with Efficient Components:

Upgrading inefficient components inside of a computer can improve a computer's overall efficiency, although higher cost is sometimes a prohibiting factor, with component upgrades sometimes requiring other prerequisite components to be replaced first. A more cost effective alternative to component upgrades is to deliberately seek the greenest computer available when it comes time for replacement.

b) Download software:

Instead of buying software on disks in plastic packaging, try to download it from the web.

Downloading S/W saves the materials, packaging, manufacturing and transport costs of a tangible copy and electronic downloads are often cheaper than their counterparts sold in the shops.

c) Green Purchasing:

Green purchasing is the most important purchasing method adopted now-a-days. Customers of every category are being encouraged for green purchasing. Each and every IT companies and individuals are moving towards green purchasing. One of the ways is purchasing electronic products having labels such as EPA Energy Star (US), TCO 95 (Sweden), and Blue Angel (Germany). This is also encouraging for the companies to manufacture greener products that consumes less power, and creates less harm to environment. Different strategies are being followed by different companies in different countries to manufacture their products green. To purchase the computers and other electronic equipment's like routers, printers, air-conditioners,etc., the following procurement initiatives could be adopted:

1. Establish standards and benchmarks to define agree purchasing policy for computers. Determine environmental evaluation criteria to compare technologies and components. Utilize reliable third party monitoring and testing organizations independent of suppliers. Use existing computer templates from systems contracting tenders as benchmarked specifications for comparative purposes.
2. Define complete purchasing policy with purpose, scope and procedures. Construct terms and conditions for future tenders and contracts. However the user departments would have to accept these terms and be willing to incorporate Eco-labels and other environmentally friendly functionality into their specifications.
3. Report/update purchase activity in support of green initiatives, including day-to-day progress to sustainability coordinator for incorporation of awareness program.

VIII. Conclusion and Future Scope

The main objective of this technology is to reduce the energy consumption of computer related products. Green computing represents a responsible way to address the issue of global warming by adopting green computing, business leaders can contribute the environmental stewardship and protect the environment while also reducing energy and paper cost. So green computing is a mindset that asks how we can satisfy the growing demand for Network computing without putting such pressure on the environment. There is an alternative way to design a processor and a system such that we don't increase demands on the environment, but still provide an increased amount of processing capability to customers to satisfy their business needs. Green computing is not about going out and designing biodegradable packaging for products. Now the time came to think about the efficiently use of computers and the resources which are non-renewable. It opens a new window for the new entrepreneur for harvesting with E-waste material and scrap computers.

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