Green Computing: An Emerging tool and discipline for Intelligent Environmental Engineering and Managerial Practice

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Abstract—

Green Computing is a valuable tool in contemporary IT and Informatics fields and practices. Green Computing is the study and research for the green friendly as well as efficient-power management based systems. Green Information Technology is related with the Green Computing though it is broad and also applicable in several allied technologies. The nomenclature of Green Computing is popular than Green IT. Both the domains are helpful for the improving environmental condition and situation. Similarly another domain called Green Information Science also has the potentialities in practices of Information Foundations and Establishment with other organizations and foundations which are computational or manual information system depended. This paper gives a brief overview of these domains and practicing facet towards eco friendly and power consumed IT and Information Infrastructure building. Green Computing is deals with various kinds of strategies as well as tools and these are depicted in this paper as a brief overview. The contemporary models and architecture in this regard also been provided.

Keywords—

Green Information Technology, Green Information Science, Energy Consumption, Power Management, Knowledge Management, Green Discipline, Eco Friendliness, Green Strategies

Introduction—

Green Computing is the designing as well as building IT devices and products with services for healthy as well as refined allied computing product designing and development. There are many

tools and devices which include monitor, printers, storage devices, networking devices and so on. It is a fact that many communication systems have now a day's prepared with very minimum or less hazard dealing materials for friendly environments. Ultimately Green Computing and IT helps in promotion of the biodegradability of the product as well as devices. Green Algorithm, Green Information Technology and Green Informatics are the smaller to broadest areas of Green Information Science (Refer Fig: 1). Green Computing is the main and core for developing eco and bio friendly information systems. Countries with developed and developing tag are now actively engaged in the activities of green, faster and smoother information systems. Green Computing and its strategies are depicted in the followings section/s with more deepness.

Objective—

This is kind of conceptual paper and mainly deal with the main aim and objective of the following,—

- To learn about the basic on Green Computing, Green Information Technology as well as their basic features and importance in brief manner.
- To know about the Environmental hazards and technologies responsible for building and designing of the Green Computing for better and healthy environmental pollution.
- To know basics of the Green related science and technologies which include Green Computing, Green Information Technology and Green Information Science.
- To learn more on Green and Energy consumed technologies and systems in brief.
- To know about the strategies of power management, virtualization etc.
- To learn about the worldwide strategies and systems adopting by the companies towards Green Computing and Technologies in brief.

Green Computing-The Benefits—

Green Computing in todays competitive age deals the life cycle of technologies such as the aspects of designing, manufacturing, use as well as disposal of products including technologies as well as research and innovation (Refer Fig: 1). For designing of a computer some of the things are very much important and urgent which include electricity, raw materials, hazards chemical too. Most of the chemical and products are accountable or intended for increasing carbon dioxide, directly or indirectly [3], [4], [5], [14]. The increasing carbon dioxide no doubt brings wider and strong Green House Gases. Practically more Green Computing practices will bring sustainability as well as Eco friendliness (See Fig: 2) . Moreover, computing and information technology is also indirectly affects the environment such as computers which normally enclose toxic material. It is a fact that in the developed countries and also in big corporations and organizations, electronic products basically ends up in landfills and here contaminating water. Therefore it indirectly affects environments and affects sustainability. There are many strategies for Green Computing and such are increasing rapidly [1], [2], [15].
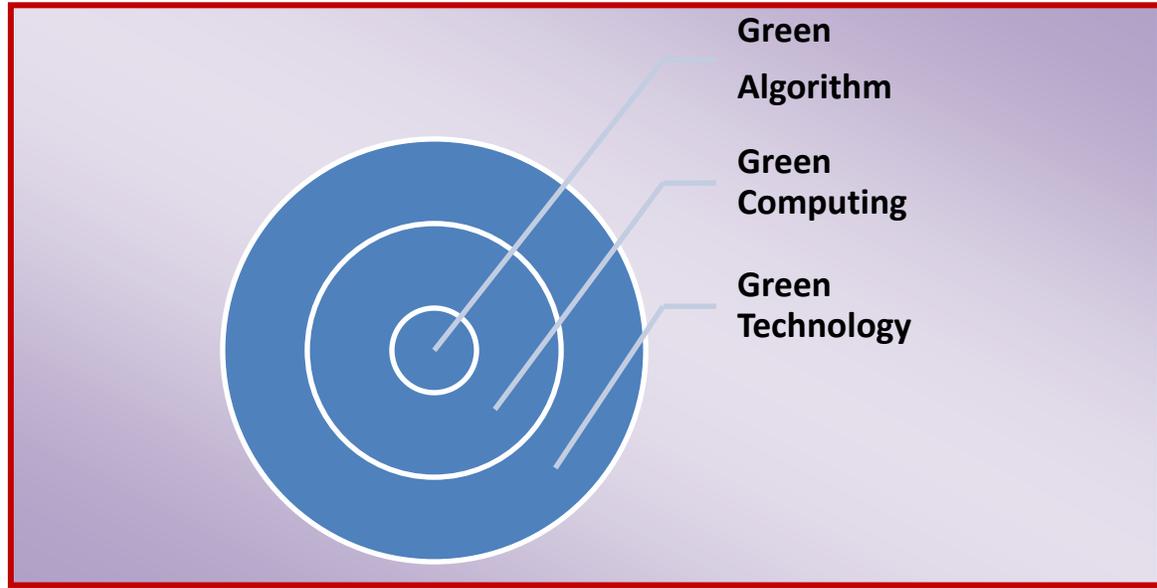
Fig: 1:- From lower to Higher Green World

Green Computing: Strategies—

Green Computing basically deals with few sophisticated techniques as well as approaches which include the optimization and power management [6], [9], [18]. Though material recycling, telecommutings are also important and valuable in many context. Few more and advance approaches are also dedicated to the healthy Green Computing systems formation. Though, it is important to note that some product longevity systems and date center designing are also most important aspects and approach of practicing healthy Green Computing as well as similar techniques [7], [10], [16].

Most of the expert categorized Green Computing as follows —
1. Product Longevity.
2. Data Center Design.
3. Software and Deployment Optimization
   (These are possible with)

   A. *Improved Algorithm*
   B. *Resource Allocation*
   C. *Cloud and Virtualization*
   D. *Terminal Servers*

4. Power Management; which includes as follows—
   (These are possible with)

A. *Data Center Power*
B. *OS Support*
C. *Power Supply and Management*
D. *Healthy Cloud Storage*
E. *Video Card and Networking Card*

***Product Longevity*—** it is a kind of approach needs to avail Green Computing i.e. practical Green Computing utilization. Frankly, the principal input to Green Computing is for protection of the equipments/tools or increases their life span [8], [11], [12].

***Designing Data Center*—**it is deals with Green Computing approaches where Data Center as well as similar establishments are competent to consume of energy. According to *Wikipedia* it is for between 1.1 % and 1.5 % of the world total energy and power utilized in 2010.

Every organizations wants to design and build separate type of hardware, software as well as application. Hence such products individually in each organization responsible for environmental prolusions and here emission of CO_2 and other Green House Gases are important factor. Ultimately it affects society as well as environment. One consortium called Data Center essentially collects all types of IT hardware as well as software amenities. Importantly these are serving to group of institutions as well as organizations with single large function. Thus it saves energy with keeping environment strong [13], [16].

***Software and Deployment Optimization*—** is a valuable approach for Green Information Technology practice. This is categorized in several ways. And here designing of smart, intelligent and improved algorithm is important and needed for healthy along with healthy software/ application development.

***Resource Allocation*—** is valuable approach for the healthy Green Computing practices. Producing better and smart utilization of resources and information is the main facet of resource allocation. Specifically algorithm is useful for better data route and circulation thus; it plays an important role for the designing of small electronic facets (such as chip or circuit). Moreover whole Information Systems designing of an organization also deals with resource allocation [17], [20].

***Virtualization*—** is a technique to introduce, computers as service center. It is also responsible for delivering computing infrastructure and systems. Virtualization is the abstraction and notion of computing as well as allied electronic resources and systems. In virtualization systems, group of computers basically connected together rationally and helps in allocation their resources to other service seeker. During 1990's the concept of virtualization emerged rapidly with a healthy

shape. Hence information technology practices basically get better and simultaneously introduce Green Computing and IT practice as it reduces power including cooling expenditure. Cloud Computing and Cloud Technology currently called as Virtualization. Here one single unit serves different clients and users thus it reduces energy and power of each individual organization. Many organizations as well as institutions are involving with virtualization like big giant Google, Microsoft, IBM, AMD, Intel Corporation, Sun Microsystems etc [19], [21].
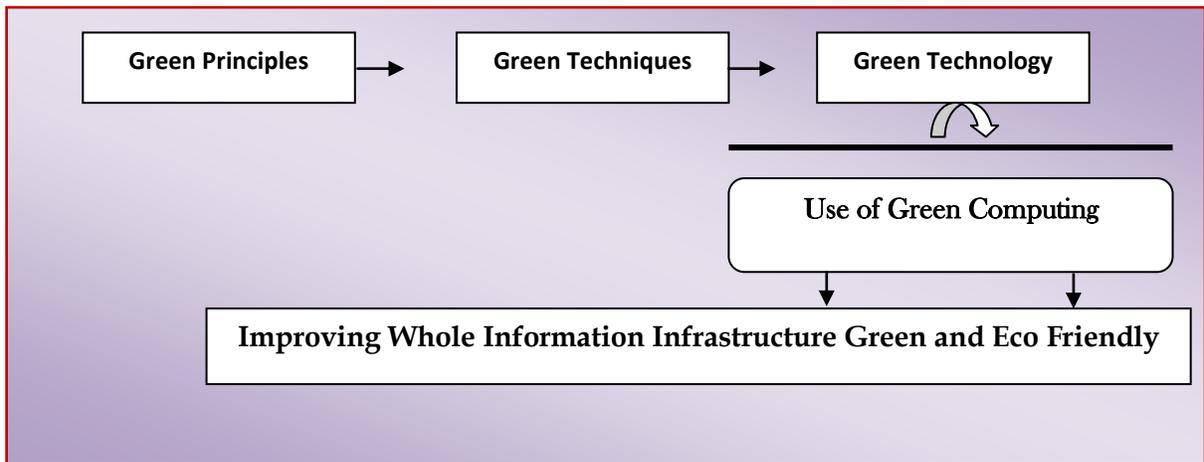

Fig: 2-The Factors responsible for Green Information Infrastructure and Systems

Terminal Server or Technologies— is a valuable techniques as well as strategy for designing, development of Green Computing. Here all the actions principally completed with centralized computer (or server) and here end user just avail such services and facilities. It is mainly combined with thin clients and ultimately capable of 1/8 amount of energy and power of a normal workstations. Thus it reduced energy cost along with consumption. Thus Virtual Lab is also promoting Green Computing and similar practices. Many softwares are accessible in the market which eventually helps in terminal server project (i.e. for the Linux OS).

Power Management in Automatic Mode— is another important system in which Energy Saving is possible. Here the performance normally done by the individual computing devices. Basically Intelligent Computer System may fetch healthy power management as in most computers, products, systems automated systems which are operational and mechanical 'switch on' or 'switch off' etc are also achievable. Hence, it is releasing less CO_2 as well as other unsafe chemical as well as product. The Advance Configuration along with Power Interface is a open industry standard that allows Operating Systems to direct control the power saving of its core hardware. Hence it is accountable for creating automated CPU system and similarly it reduces energy and power of individual computers. Even depending upon need system may allow *'switch off'* the Central Processing Unit or RAM. In many cases BIOS is treated mainly for Power Management function.

Based on designing as well as development of some programs, it is moreover allow the user to set physical voltage supplied to the CPU. Hence ultimately it reduces amount of heat and electricity or power management. This is considered as underwriting. Thus many IT product manufacturers are basically designed processors and similar systems which are automated processor adjustable.

Data Center Power—is another significant step in power management and optimization for Eco Friendly Computing practices. Data Center basically is able to get better their energy and space competence by several techniques which include the consolidation and virtualization of storage. Today many organizations and institutions are poignant towards healthy Data Center dynamically which ultimately results better Energy Management.

Operating System— is another important and most valuable tool for power and energy management. Most of the Operating System manufacturers are designing having better speed with processing system and thus helpful in managing Energy Consumption than that of conventional operating system. Microsoft Corporation started Energy Consumption from Windows-98 with standby and a monitor low power state. Thereafter Microsoft and other leading O/S companies have launched the system healthy power management. Organizations are normally wants fast, speedy information processing and ultimately such OS helps in Energy and power consumption. Building or designing of O/S for Energy Management requires unique as well as unusual system architecture including new hardware driver model. Many OS tender Active Directory Integration and unique single or per user and per machine setting with smart power management systems which eventually helps in Green Computing practice in several perspective. Few important offering are include—

- *Multiple Power Plans.*
- *Scheduled Power Plans.*
- *Anti Insomnia Features.*
- *Enterprise Power usage Reporting.*

Power Supply is appreciably important aspects of power and energy management. In this system PC power supplied as usual 70-75% efficient dissipating the remaining power or energy as heat. As Wikipedia mention as on July, 20, 2007, all new Energy Star 4.0 certified desktop PSU's need to be at least 80% efficient.

Another valuable aspect of Power Management is storage and responsible for energy consumption; indirectly that bring eco friendliness. This is comprises with IT product manufacturer and moving towards Green efficient storage systems. Even organizations are also using small hard disk drive that ultimately saves energy and power many ways (than that of big hard disk drive). Utilization of solid state enable storage system is also accountable for power

management important friendly. Such storage systems are built in built with non-measurable parts. Hence it keeps followed Green Computing agenda. According to Wikipedia it is noted that chief Data Center service provider MySpace avail around 80 % Energy saving by using healthy solid static Data Storage mechanism [19], [21].

Another imperative approach is Data Storage for power management using offline storage including backup data. And, ultimately it is also responsible for improving Power Management systems. Data backup and archives data that formerly have been saved office storage may also get the benefit of the same. Flash Memory/ DRAM etc required in many cases for power management for individual computers or even for the big Data Center.

Video Card— covers the approach towards power management, it is essential to keep the computers without video card unless not in use. This uses shared-terminal, shared-thin client, desktop sharing software based on display need. Selecting a GPU based on low idle power, average wattage. Using motherboard and video output is also most important approaches and strategy for power management.

Display—is another significant approach for Power Management thus, organizations and companies are using only such display units having reputed energy and power management approach. Cathode Ray Tube is also used for more power than LCD monitors. It is also associated with the harmful lead and thus not suitable for sustainable environment. However use of LCD monitors instead of CRT is remain less energy consumed. Thus it also deals with less and harmful material. LCD is clod cathode fluorescent bulb based and helps to provide light for the display.

Light Emitting Diodes (LED) is most important tool for the Energy Management due to its reduced amount of electricity used by the display. Fluorescent is important in LED whereas LED not contains any such material. Hence the display plays a supporting role for Green Computing and Technology practices.

Material Recycling is also helps to building and designing Green Computing many ways. In broader sense the concept is includes following *(but not limited to)*
- *Electronic Waste.*
- *Computer Recycling.*
- *Waste Electrical and Electronic Equipment Directive.*

The Silicon Valley toxics coalition estimates that 80% of the postconsumer E-Waste collected for the recycling. And which is transferred overseas to countries like China and Pakistan (*According to Wikipedia*). Throughout recycling of computer product the attention of Hard disk is very important as hard disk keeps all the data and storage within its memory even after delete

the matter from the computers. Hence it is necessary that few official hardware recycling companies need to establish. Recycling is also helps in healthy Green and Eco Computing practice. E-Waste management with recycling is most urgent requirement for healthy and sophisticated computing infrastructure.

Telecommuting— it is another tool as well as approach for building a healthy Green Computing practices. Tele-commuting is includes employing Tele-Presence technique which ultimately helps in better and healthy computing resource delivery with very smallest amount energy and also time saving. Tele commuting ultimately practices and increased the worker satisfaction, reduction of Green house gas so on. There are many technologies that are using for better VoIP as well as Cloud Computing practices and these are most important and dear. Ultimately VoIP reduces the telephony wiring and similar infrastructure by sharing of earlier, conventional Ethernet copper.

Telecommuting no doubt also saves the organizational energy including professionals. Here importantly, personal attention is not required but here online support of health and sophisticated communication possible many ways. Moreover a study results that yearly energy consumption of office building for United States is 23 KW+ hours per square foot; i.e. combining with heat, air condition including lighting it keeps 70% energy consumed.

ICT energy consumption in the USA and worldwide increasing and thus Tele-commuting has a good and healthy potential for energy utilization.

Tele Communication Network Device— practices also promote energy consumption and friendliness for the healthy wider Green computing practice. Particularly the network device designers as well as builder are rising in designing of intelligent network product designing which take less time for information processing and needs less energy for the activities. Organizations worldwide are going to sophisticated network practice including the use of wireless network devices as well as intelligent network product designing.

*Super Computer—*also supports Green Computing and Green ICT practice many cases. General organizations and IT organizations suggested that super computer uses are very much obliging for power consumption due to its approaches towards energy. Super computer also keeps the organization eco friendly. According to Wikipedia the TSUBAME-KFC-GSIC Center is today has the great advantage to the second top supercomputer with 4,503.7 MFLOPS/W and 27.78 with Total Powers K.W worldwide. Hence these are the main approaches towards healthy Green ICT introduction. However research availing much area towards modern and intelligent Green Computing practice [15], [21].

Green Computing and Green Information Technology practices may be possible with the application of following —

Green Use—It minimizes general energy and power consumption of the computing along with similar other Information for eco and green friendliness.

Green Disposal— Recycling of computer with the disposal of computer, electronic gadget are important for Eco friendly computing and IT systems practice. Reuse/ replacement i.e. recycling of product or devices may be another alternative may be chosen.

Green Design— Green Design is valuable tool for sophisticated computing, electronic system designing. Energy consumed algorithm, product, display designing etc normally gets most important priority here [14], [20], [21].

Green Manufacturing—Green product designing, planning and building is another most important feature of Green Computing in which all the products including computer, printer, network devices, software etc need to build with power management principles.

Green Purchasing—User and buyer need to purchase only the products/tools that are built according to Green principles. Here use of label i.e. popular certification *may* acquired including (but not limited to)—

- EPA Energy Star, US.
- TCO 95, Sweden.
- Blue Angel, Germany.

Findings—

- Use and utilization of proper and healthy load balancing techniques basically promotes Green Information Systems.
- Cloud Computing services need to put more importance to brings users under one umbrella and circle.
- Green Computing initiatives in industry, academia and government sectors are emerging worldwide.
- Manufacturer are providing much attention in designing of more efficient, accurate green systems and many of these are uses more energy.
- Though in another side organization as well as manufacturer are concerning R/D activities for the progress of IT products that are less harmful chemical, material.
- Awareness regarding Green Computing and IT is limited in the developing countries and thus it is a issue.

Suggestion—

- Uses of Green Computing need to practice in the organizations and companies in all sectors and thus planning, initiative etc are required promptly.
- Cloud Computing and similar one Green Computing also desires modern policy for its real accomplishment.
- Cloud Computing including Green Computing etc include in the curriculum Computer Science, Information Technology, Software Engineering, Information Science etc for its real practices.
- Proper and healthy financing among the user and common people of Green Computing and Cloud Computing in Industries, Service Sector and even home are urgently required.

Conclusion—

Several associations, foundations, organizations and institutions and government actively engaged in Environment these days. Planning and implementing them into reality is an important facet. Computing as well as most electronic gadgets are major issues these days for Green systems and atmosphere building. It is a fact that many Electronic devices are designed and builds with harmful chemical etc. It is a fact that there are many cause for which manufacturer as well as service provider including concerned organization are involving designing, development, implementing of Green Technology and principles. Academician also need to build new curriculum, module, programs that the green system should promote by the academic side also.

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