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## Importance of Green Computing In Digital World

Mr.R.Karthikeyan<sup>1</sup>, Mr.B.Senthilkumar<sup>2</sup>, Mr.G.Vinoth<sup>3</sup>

Assistant Professor, Department of Master of Computer Applications, Gnanamani College of Technology,  
Tamil Nadu, India<sup>1</sup>

PG Scholar, Department of Master of Computer Applications, Gnanamani College of Technology,  
Tamil Nadu, India<sup>2</sup>

PG Scholar, Department of Master of Computer Applications, Gnanamani College of Technology,  
Tamil Nadu, India<sup>3</sup>

**ABSTRACT:** The green computing is one of the recent and prominent research fields where many researchers are working on finding the efficient way to use energy in an efficient manner. The two ways in which the researchers look into green computing are mainly concentrating on the energy efficiency and power consumption and other way is making the green software to thrive the industry and make innovatory products. Many corporate organizations are taking initiatives to reduce the harmful impact of their operations on the environment. Green computing refers to the practice of environmentally responsible and efficient use of computing resources while maintaining economic viability and improving its performance in eco-friendly way. In the article author has made a systematic study on several strategies and developments in context to the ICT sustainability as a future asset of growth for modern society. The article focuses on the practices like use, disposal, design and manufacturing as well as on technology based-solutions like electronic products and services e.g. green cloud. The outlook for greener ICT should include using the Internet as a powerful agenda for promotion and education for environmentally aware behavior and as a useful tool for creating eco-friendly technology.

**KEYWORDS:** Green Computing, Power Management, Sustainability, Eco-Friendly Technology, Energy Efficiency.

### I. INTRODUCTION

The green computing is an interesting and also efficient research area which has grabbed the attention of many in recent days. It is because the pollution or effect of harmful rays in the environment has started to affect the health of the individuals directly. So the use of the green computing techniques and the alternative options which consumes less energy can help the people in saving the environment. In this paper, a thorough study on the various causes and the remedies that can be followed to live in a green world has been discussed. There are certain green applications which will replace the energy consuming applications in an efficient manner. The number of difficulties that are faced by the individuals while going for the implementation of the green computing technology is high. It is because the green computing is totally new to the society and is creating confusion among the individuals on what green computing actually is. The green computing concentrates mainly on the software development without consuming more time and energy along with the selection and usage of hardware which will not need high support of power resources (Gung and Hence, 2009). Each and every application or changes made in the existing system resulting in the ultimate energy saving motto is considered to be part of green computing journal. The demand for researchers in this field of green technologies has increased to a greater extent. Here we are discussing the various ways in which one can avoid power consumption, approaches relating to green initiatives and the common applications which will serve the environment in its best way for contributing a little in saving the energy consumed. Green computing is the term referring to efficient use of resources in computing and IT/IS infrastructure. Efficiency of green computing emphasizes on mineralizing



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hazardous environmental impact in conjunction with achieving economic viability and improved system performance. The field of “green technology” covers a board spectrum of subjects – from alternative energy-generation and electricity consumption techniques and use of eco-friendly, recyclable materials to implementing sustainable digital services. Technical issues of green technology includes: green infrastructure (energy-efficient buildings, intelligent cooling systems, renewable power sources), green hardware (multicore computing systems, energy efficient server design and solid-state storage and green software and applications - parallelizing computational science algorithms to run on modern energy efficient multi-core clusters, intelligent load distribution and CPU switch-off (Snell, Weinberg, Katz, Yun, Wilson, Narayanan, Mo, Calzetti, Moss, Shenoy, Weems, p. 1).

## II. POWER CONSUMPTION THROUGH SOFTWARE

### Efficient Algorithm / Green Algorithm

It is quite common for calling a programmer who program shortly as a good programmer when compared to the one who writes program for pages (Developing Green Software, 2011). It is because the efficiency is obtained in speed and saving energy also when the number of lines of codes to be considered and the load on the processor is less. Thus the algorithms or data structures that are concentrating on the research in computer science will look forward the algorithms that can make a vast difference in factors like the performance of an application. In other words, in some cases the programmers can use the stack instead of queue and can even go for B-tree than binary tree or a hash function. The best algorithm or data structure selection itself covers most of the achieving steps of efficiency of the programs.

The green algorithm is one such sort of algorithm which his concentrating only on this sort of selection of better algorithm or data structure to achieve the efficiency in a power saving and heat conserving manner.

### Multithreading

When the time taken for computing a task takes more time then the energy consumed for completing that task will also take longer time. Instead of computing the long or complex programs in a single thread, it will probably any individual to go for multithreading. The multithreading is a very well known concept where the same complex process can be run parallel thus conserving the energy and the time needed for computation of the same problem. The use of Graphic Processing Unit (GPU) instead of CPU for computing larger data mass is considered to be a wise and green idea. which is also highly needed in the current scenario for the world. The efficiency of the system is also considered to be increasing with the introduction of multithreading in a complex system as in other program.

### Pre-Fetching and Caching

From the study conducted by Intel in (Developing Green Software, 2011), it is found that the process of pre-fetching and caching of instruction is helping in saving lots of energy. The prefetching and caching is one such sort of process where the instructions which needs to be executed for the next process will be fetched from its memory and is sent to the cache. Thus the instruction will be stored temporarily and can be accessed directly from the cache without searching in the memory. The green computing comes here when the energy is saved in the time reduction of searching for the instruction in the internal memory architecture of the system.

## III. GREEN INITIATIVES IN GREEN APPROACHES

### Virtualization

The virtualization concept came into existence only because of the need to saving the excessive use of individual systems. The virtualization is one such sort of technology which is giving provision or the users in accessing the servers from a remote area. The advantageous factor regarding this is that the individuals can combine many physical systems into a single integrated system and hence the original hardware and system can be unplugged resulting in reducing power and cooling consumption. Instead of setting a server and a cooling system for that, it will be better to access a big system server in a virtualized manner (Green Computing, 2013). The concept of virtualization is best suitable in the Green computing area because it can save power and can also cut costs breaking the link between

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the applications, application components, system services and storage systems. The existence of virtualization is supporting green computing in many forms. Green initiative nowadays moved into the concept of virtualization where cloud computing plays a major role in that. The statistics of cloud users based upon the benefits provided by them has been increased sufficiently for last two years. The image shown below explains clearly about the cloud benefits for the year 2014 vs 2013.

## Power Management

The need for power management in any computer system is highly insisted because of the prolonged battery life, reduction in the cooling requirements, noise also. The costs needed for operation of the system is also considered to be one of the main reason for the individuals to concentrate more on the power management support in the system resulting in the stability of the system leading to probable maintenance of the impact that it can create on the environment. The hibernate option available in the system is one such kind of power management technique which is been supported in a wide and efficient manner as it will automatically switch off the RAM and CPU of the system reducing the amount of background working of the system. There are certain programs available nowadays that can actually alter even the voltages of the system probably resulting in the reduction of the heat produced and electricity consumed in the system which is generally called as under voting.

## Power Supply

Power supplies is also one such factor which will actually help in achieving the green computing concept by implementing the green systems. The drain of more power is supportive in designing a system in an efficient manner.

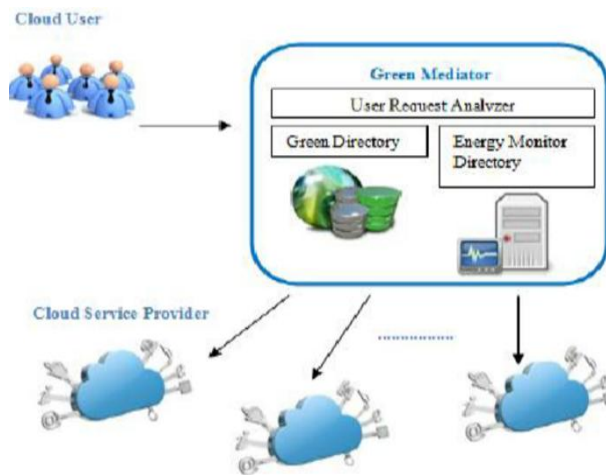


Figure 1 Green Computing Architecture

## IV. LATEST DEVELOPMENTS

### Green Cloud Computing

The Gartner report from May 2009 defines cloud concept as “a style of computing where scalable and elastic IT capabilities are provided as a service to multiple customers using Internet technologies”. The 1856 use of the potential of cloud computing model interacts with the concept of sustainable development, understood in three dimensions: economic, environmental and social. Clouds consolidate environment, saving power, cooling, space and money. Cost savings and flexibility of operations are among the most frequently mentioned benefits associated with a decision to adopt the cloud computing solution. Fixed costs related to the investment in infrastructure (which in the traditional business model generally increases with time and the need to update the software) are reduced, as well as energy costs feeding the infrastructure. Traditional costs related with the licenses, number of users, equipment,



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operation, repairs and applications are replaced for payment for functionality that is actually used by the company or other organization that also obtain access to the latest technology. This solution allows adjusting supply to demand, eliminating incurring unnecessary costs associated with the overestimation or underestimation of customer needs. At the same time, it affects the reduction of occurrence of lost sales opportunities risk and cost of incorrect demand forecasting and company's supply planning. Some aspects of cloud's ICT infrastructure allow identifying the model as the one providing green benefits. The basic features of the model allow you to specify a number of environmental benefits that can be achieved by migrating the IT resources to the cloud. These aspects may include:

- **Dynamic provisioning and multi tenancy:** Automatic processing of computing environment supports user needs, operating under the cloud may acquire or release the resources (instances) where it is appropriate (according to the demand). Dynamic resource allocation is done automatically, thus datacenters maintain active servers according to current demand. With virtualization technology, which allows connecting disparate resources in one great set of resources it is possible to release them more selectively to all customers at the same time increasing the level of their use.
- **Optimal server utilization:** traditionally, many servers remain idle of 85-95% of the time using nearly as much power as they do when they are active. Virtualization technology enables hosting of multiple applications through one server. The number of active servers is reduced and the power consumption is lower.
- **Energy-efficient client devices:** the public cloud model reduces the number of energy consuming clients through small energy-efficient devices (e.g. thin clients)

## Carbon Aware Green Cloud Architecture

Green cloud architecture is one of the latest developments of green computing idea. The aim of this unified solution is to deliver both users and providers, high-level architecture for supporting energy efficient service allocation which is based on cloud technology. Cloud providers, being profit oriented are looking for solutions which can lower their electricity bills without losing their market share. The goal of satisfying the demand for high-level computing services on the user's side and saving energy on the provider's side, can now be achieved by implementing the green cloud infrastructure. The architecture for supporting energy-efficient service allocation in green cloud computing infrastructure. The cloud services (SaaS, PaaS, IaaS) are registered in the form of public offering in Green Offer Directory. The Green Broker has the full access to all services which are available and registered in public directory. Green Offer directory is incentive for the providers who, list their services with discounted prices and green hours. A typical cloud broker lease cloud services and schedule applications Green broker's responsibility is to select these offerings in terms of requirements of end user. Each request is analyzed according to the price, time and service that offer the highest quality and least CO2 emission. Green broker uses the up to date information about cloud services and current status of energy efficiency parameters using Carbon Emission Directory (CED) which is very important component of the architecture. CED may include some the crucial green metrics power measurement like: Power Usage Effectiveness (PUE) – which is the fraction of total energy consumed by the service of a data centre to the total energy consumed by IT equipment, some cooling efficiency indicators like Water Usage Effectiveness (CUE) – which is the calculation of greenhouse gasses (CO<sub>2</sub>, CH<sub>4</sub>) release on atmosphere by the data centre (Atrey, Jain & Iyengar, 2013, p. 96) and carbon footprint In general green cloud framework enables end user to access to all three types of cloud services through one of the deployment models: private cloud (hosted and operated internally within and by a single organization), public cloud (computing resources are shared by several subscribers via Internet in a pay-as-you-go manner) or hybrid cloud (the organization stores and processes critical data inhouse in a private cloud and non-critical data is outsourced to the public cloud when needed).

## Green manufacturing

Major IT companies are already applying green standards to their own operations in order to: gain new revenue opportunities and promote social and environmental responsibility influencing customers and market competition. Main areas in green manufacturing of computers are:

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• **Eco-friendly design:** the design of computing resources that meet the stringent restriction of e.g. Energy Star enabling further utilization with determined power supply and power management requirements (including special modes and allowances).

• Use of bio-products: biodegradable and renewable materials often requires less energy to produce in comparison to traditional toxic materials.

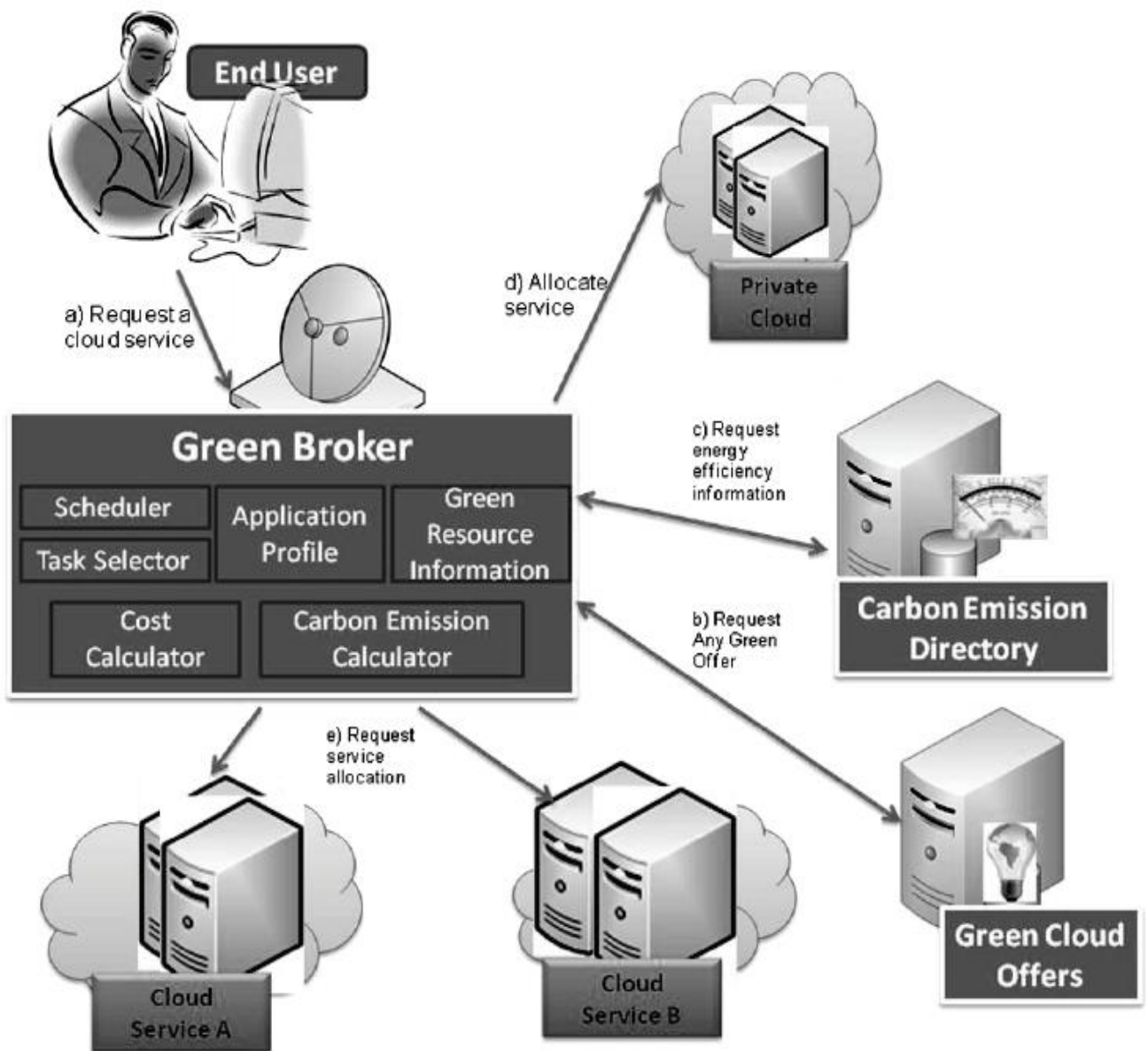


Figure 2 Carbon Aware Green Cloud Architecture



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## V. CONCLUSIONS

We know that all companies are moving towards the green computing in order to improve the efficiency of resources they have and to reduce the hazardous pollutions creating by the companies. Last few years, because of these problems companies are forced to migrate into the cloud computing which is a form of green computing. Lots of researches are going in order to improve the quality of the green computing by developing the low power consuming software's and recycling the electronic wastes. If we want to really support the green computing it's our individual responsibility to GO Green. In the coming years there is a scope of lot of research work that needs to be done in the field of green computing. Research could be concentrated around making data centers and cloud computing more energy efficient. The corporate organizations must take more green initiatives. All stake holders must work jointly for a greener world. Otherwise, the human race will face severe problems in the coming years. There are as such no limitations of this survey but in future it is expected that there will be lot of research related to green computing. That is the scope of future improvement of this work.

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