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# Green computing through modeling network servers and power reduction in portable devices through solar energy

FATIMA ZOHRA, MISBAH IQBAL & M. FAHAD KHAN
University of Engineering and Technology, Taxila, Pakistan
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ABSTRACT Due to the rapid development of green cloud computing amenities in the recent times it is important to examine the variety of current energy usage patterns within the context of Green computing. Green computing has different working areas like green use, green design, green manufacturing and green disposal. These areas are used to design, manufacture and compute all the computing devices in such a way that reduce their power consumption, resource utilization and the effects on the environment. As a result, energy efficient resource management (green design) and the reduction in the consumption of electricity (green use) have become critical issues in green computing. In this paper, we examine these issues and the best possible techniques and strategies to confront these challenges in networks. We also examine smartphones utilization, challenges of battery life time, as well propose methodology of greener approach to energy consumption of smartphones and related portable devices.

*Keywords:* Green computing, Core networks, Data centers, Energy consumption, Solar computing, Smartphone

## Introduction

One of the crucial concerns for many industries is the decrease in energy consumption due to certain environmental, marketing and financial reasons. These issues may have a huge impact on the networking domain. For example, highly accessible and high performance machines are involved in networking set-ups and architectures. These frameworks are intended to tolerate the dishonored conditions and the ultimate extreme load cases which, in normal scenarios, are less utilized, stimulating the need of saving energy. In recent time, concerted efforts have been made across the globe to minimize the redundant energy expense—commonly termed *green networking* of network protocols and methodologies.

Various studies have shown that the rapidly increasing demands of users in the domain of network based computing may increase the overall data center's deployment costs and operational costs with a great focus on its environmental effects (see for example Uddin, et al., 2011). A recent analysis suggests that the power consumption of such data centers has reached billions of kWh which sometimes costs up to 42% of a company's monthly budget. There is also a suggestion that energy consumption utilizes almost 0.5% of the *Ecosphere's* total electricity (Younge, et al., 2010). It has also been observed that the energy required by servers and the consumption rate of energy for their cooling purpose becomes double every year. Consequently, energy efficiency and its impacts on system performance, networks and environment become critical issues in ICT and demands greater attention. Thus, green computing arises out of a general concern for energy efficiency in computing.

There are four aspects to green computing—these are green use, green disposal, green design and green manufacturing. In green use, the main focus is on minimizing and reducing the consumption of electricity in computer networks and other devices without compromising on their efficiency. In green disposal, recycling or remaking or disposal of an old or already made computer is done. This computer or electronic device may be out of date, expired or no more in use. In green design, the focus is on designing energy-efficient computers, electronic devices, computer networks so that the devices might consume minimum electricity/power. The latter is a proactive approach. In green manufacturing, the goal is to minimize the waste materials and other hazardous environmental effects during the manufacturing of electronic devices that disturb the ecosystem of the universe (Green ICT Guide, 2100).

In summary, green computing refers to the environment and eco-friendly use of computers by minimizing the power and resources consumption in computer networks and/or in individual PCs. Green computing focuses not only on the energy balancing techniques, but also on the factors that might minimize the emission of Carbon Dioxide gas during any computation. Green computing is also known as green technology—i.e. the implementation of energy-efficient or power-balancing central processing units (CPUs) servers as well as their peripheral devices (Biswajit, 2014).

In a broader sense, across the globe, preserving the resources of the earth is a desirable objective. According to Udin et al (2011), energy proficiency and productivity are becoming important for the future of ICT (Information and Communication Technology). With an increasingly interconnected world—via desktop computers, electronic devices, PDAs, smart phones, computer networks—the demand for power is increasing. The research on green computing and its practices started 1992, when the Environmental Protection Agency [EPA] (2006) launched the Energy Star Program. The report characterized cloud computing as critical to green computing as well as highlighted important *traits* of energy-efficiency and resource-efficiency.

## Literature review on green computing

Before trying to directly focus on the ways of reducing energy in networks, it is essential to find out the areas where these improvements could takes place. Internet can be segmented into central network and different type of accessing networks. These different segments have different levels of equipment to be used as well as expected performance and energy consumption. According to Roth (2012)'s study of energy usage level of various classes of equipment for the internet, 80% of the total internet usage is consumed by hubs and switches of local area networks. Similarly, in 2005, Roth (2012) assesses the quantified influence of Network Interface cards and other elements of network. Lange (2009) reports a prediction by Deutsche Telekom that, by the year of 2017, a decreasing trend in consumption of network core might [ultimately] become equal to the power consumption level of network access. View in this context, consumption level should be traced and assessed regularly.

There are two levels of networks at which energy efficiency is attained—i.e. at the infrastructure [routers and switches] level or at node [NIC] level. The word "Green Networking" is usually referred to the concerns about energy efficiency and consumption as relate to networks. Current categories of solution to actualizing goals of green computing [as identified in the literature] include: virtualization, resource consolidation, selective connectedness and proportional computing. *Resource consolidation* focuses on the overall consumption of resources by reordering the available machines or devices. *Selective connectedness* of devices (disseminated mechanisms). *Virtualization* aids hardware utilization. *Proportional computing* is useful and applicable to the whole system. Examples of proportional computing include Dynamic Voltage Scaling (DVS) and Adaptive Link Rate (ALR). See also Bainzino et al. (2011) for an extensive discourse on green computing.

However, the following paragraphs highlight a number of techniques applicable in the domain of green computing:

*Virtualization*

In the virtualization technique, different computers can be run on single but powerful machine hardware. Only this powerful machine consumes power as well as act as a source of power for the other virtual machines – reduced electricity utilization.

*Power Management*

Power management is another concept which aims reducing power/electricity utilization. By virtue of power management it is possible to increase battery life of mobile devices, to cite an example. It is also possible to minimize the noise pollution and energy consumption by virtue of a reduced emission of heat from the machines – hence less emission of carbon dioxide.

*Displays*

Old fluorescent light displays can now be replaced with newer versions of LCDs (Liquid Crystal Displays) and LEDs (Light Emitting Diodes) that are consume less energy. These displays are energy efficient than old CRT (Cathode Ray Tube) displays.

*Materials Recycling*

Materials recycling technique used machines or computers are recycled which are then sold on to at low prices to organizations that need them or, sometime, give away to local charity. It is also possible to re-use some parts of the machine in the reassembling of other systems.

*Solar Computing*

Solar computing is a promising concept in green computing. It is a reliable and efficient technique that uses solar power through solar panels. It is suitable mostly for hot climatic regions as well as operate*able* in dusty conditions.

In this paper, we are focusing, energy efficiency in the field of networks while reducing its impacts on environment which is the key role of green computing. In business terms, it is considered as the solution for the reduction of the operational and deployment cost i.e. IT waste recycling (Baliga, et al., 2011). Turning servers on and off, dynamic voltage and frequency scaling (DVFS) and putting the servers in sleep state are considered as the basic energy efficient techniques. Huge reduction in power consumption can be achieved by decreasing the voltage supply and minimizing the clock speed with uncertain loss in performance. The point that should be noticed is to minimize the power/energy consumption while the overall system performance should not be affected.

## Proposed methodology

This section is divided into two general computing devices—these are desktop machines [servers] and Portable devices [PDA's and smart phones].

*Minimizing the power of consumption in computer networks*

Having highlighted some of the major challenges facing industries in the area of energy consumption, the following paragraphs will attempt to propose a solution design to minimize the power consumption in computer networks or servers. To start with, consider a network of server attached to each other in which several servers respond to user requests at run time. It is unpredictable to which the server the next request will come. And, in order to fulfill this critical non-functional requirement of availability, although all servers must be in power ON mode, but availability of servers [in this context] is a most crucial requirement. This latter approach might look simple, but it does have some drawbacks. Why? Since the servers [in question] are active round the clock, whether or not they receive requests, they are consuming a significant amount of resources like power, memory, etc. There is, therefore, a need for a model that will shrink this consumption to an acceptable level. In order to solve this problem let us consider a model as depicted in figure 1 on page 24.

1. All machines are connected to each other through a network [but only one at a time] while one machine acts as a server.
2. The machine in question will act as a primary server (A) while the machine immediately next to it acts as a secondary server (B).
3. The primary server will have the IP addresses and MAC addresses of all the connected machines/servers in the network.
4. Also, the primary server will have updates requisite information on the secondary server in the event of an emergency.

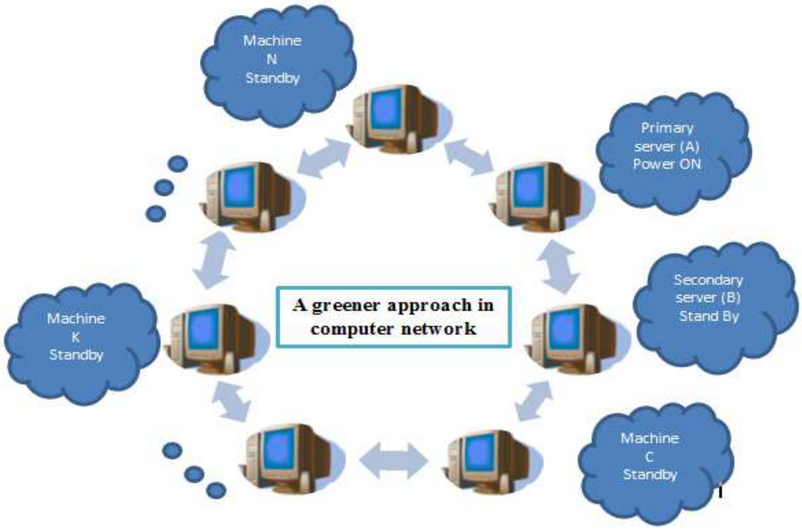


*Figure 1: the Initially proposed computer network*

5. The primary server will be on power ON mode round-the-clock (24x7), while the rest of the machines will be on standby mode (thereby consuming far less energy than the primary server).
6. Whenever a user request comes, it will be handled by the primary server whilst deciding, for example, which machine in the network such request is meant for.
7. Once such decision has been made, the primary server will then call that machine in question into power ON mode so as to handle the request.
8. After responding to that request/service, the server will again return to its standby mode until it receives a new request.

In this way, the network is handling the user requests one at a time using the accounting principle of First-in First-out or FIFO. This approach does have a major drawback which is discussed following paragraphs:

*Problem*

The major problem occurs when the primary server is crashed. Should that happens, the secondary server will, automatically, act as the primary server and the server next to it [server C] will act as the secondary server. Additionally, the new primary server (B) has to copy all the information about the network and the connected machines to server C [the new secondary server]. This process will be triggered whenever there is a server crash.

Two main issues are:

- *Security:* Transferring data related to the machines in the network to the secondary server whenever the primary server crashes might not be as secure as it looks. Data might get distorted or damaged during transmission which might lead to chaos of sorts.
- *Power loss:* It is more difficult to transfer data as compared of merely storing it because it takes more power to transfer data in network as compared to merely storing it. It has been established when data is transferred over a network it consumes more energy.

To address these issues—i.e. that server A will not experience a crash, the following is computer network model is proposed as depicted in figure 2:

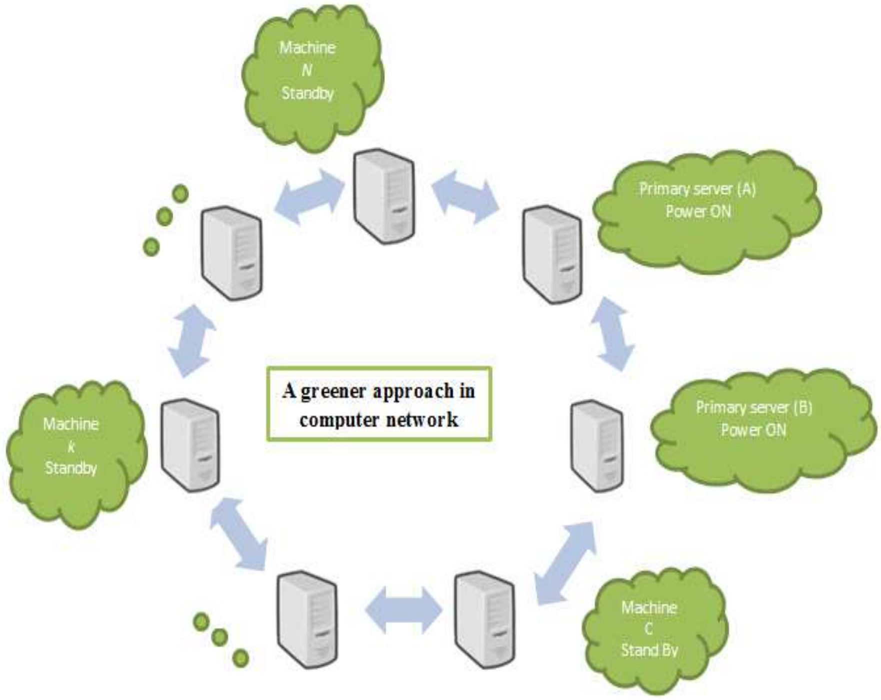


*Figure 2: Final proposed computer network model*

The major reason why server A might crash is that it receives requests that are far beyond its capacity. To prevent this from happening, we have to do *load balancing* on the server so that it does not have to reach a crashing point. Accordingly, if the server A reaches its peak, further requests are automatically transferred to or handled by the secondary server B. In this case both servers A and B are running in parallel and handling user requests. This can be achieved by performing stress and load testing on server A and then distributing the number of requests it is handling. Though it will consume power because of two active servers but it will be much less than the power consumed during transmission of data—as shown in figure on page 25.

## Minimizing the power consumption in smart phones

Smartphones are increasingly popular due to their 'smart' use. The popular use and constant updates—even in if not is used—meant that these phones require constant recharging as batteries alone might unable to cope with the usage demand. This has become a major problem requiring solution that has so far eluded many manufacturers. To address this problem—i.e. balancing energy consumption in smartphones—we focus in this paper on the concept of green computing not only for computers linked to a network but also on green computing techniques in mobile phones.

One possibility can be to add a micro solar chip or panel on the mobile devices itself that will automatically recharge the battery through solar light all day. It could be in the form of a clear transparent panel that resides on the screen of the smart phone. Even when the smartphone is off it will automatically trickle down the sun light into battery by converting it into electricity. And when the phone is on it will also convert the screen light it is emitting into the electricity. Although this *photovoltaic solar panel* is not supplying all the power that is needed to fully charge the battery but still it is providing a significant amount for the cell phones to keep running until a socket could be found to recharge. This thin layer of photovoltaic solar panel is almost invisible to the human eye and might not be detectable—as shown in figure 3.

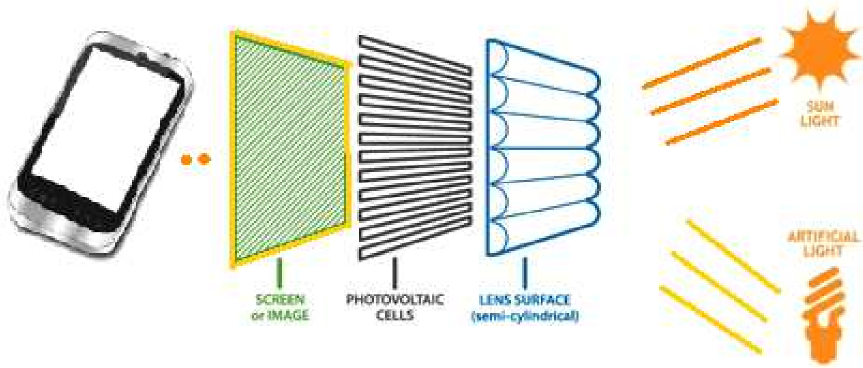


*Figure 3: Almost invincibility of the thin layer of photovoltaic solar panel*

This proposed model is not just restricted to smartphones or mobile applications. This energy-regenerating technology is also applicable to tablets, E-readers, Notebooks and other low-power portable devices**.**

## Potential limitations of the proposed models

There are a number of limitations to the application of the proposed models, but this paper will highlight a couple of significant limitations. First, there might be a challenge of implementation as people—faced with a greener approach to computing—might not have the capacity to implement 'in true spirit'. Second, the proposed methodology will require a changed in infrastructure requiring re-configurations of all servers and other computing devices on the network. Initially, therefore, the new system might not be user-friendly.

## Conclusion

Green computing is an emerging feature in technology. A number of techniques, methods and models are described to improve energy efficiency factor in various fields of green computing such as green use, green disposal, green design and green manufacture. This paper focuses on the concept of green design i.e. greener approach in networks. A proposed methodology describes a way of reducing power consumption in computer networks by arranging servers or machines in such a way that they continue to provide service to the user without a fear or concern of the system being crashed or shutdown due to power loss. This paper also examines green computing as applied to the use of smartphones and related portable devices. A significant rise in the use of mobile/smartphones in recent years has drawn attention to the issue of battery lifetime. To address this concern, this paper also proposes a solution to dealing with power consumption of smartphones.

*Correspondence*

Fatima Zohra, Software Engr
Software Department
University of Engineering and Technology, Taxila
Pakistan
Email: chunkbar@yahoo.co
Tel: +923455065079

Misbah Iqbal, Software Engr
Software Department
University of Engineering and Technology, Taxila
Pakistan
Email: misbah_iqbal2k9@yahoo.co
Tel: +923345020880

M. Fahad Khan, Associate Professor
Software Department
University of Engineering and Technology, Taxila
Pakistan
Email: fahad.khan@uettaxila.edu.p
Tel: +9251- 9047746

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