Chapter 65
Green and Energy-Efficient Computing Architecture for E-Learning

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ABSTRACT

Information and Communication Technology (ICT) is one of the fast growing industries that facilitate many latest services to the users and therefore, the number of users is increasing rapidly. The usage of ICT and its life cycle produce hazardous substances that need to be addressed in efficient and green ways. The adoption of green computing involves many improvements and provide energy-efficiency services for data centers, power management and cloud computing. Cloud computing is a highly scalable and cost-effective infrastructure for running Web applications. However, the growing demand of Cloud infrastructure has drastically increased the energy consumption of data centers, which has become a critical issue. Hence, energy-efficient solutions are required to minimize the impact of Cloud environment. E-learning methodology is an example of Green computing. Thus, it is proposed a Green Cloud Computing Architecture for e-Learning Applications that can lower expenses and reduce energy consumption.

INTRODUCTION

Energy consumption is a bottleneck for Information computing and communication. Internet has provided an unlimited potential with access to eBooks, multimedia content, news, new ideas, and information access in general but, due to poor broadband infrastructure and available grid power to support the Internet and ICT growth the, developing regions have actually been left even further behind. The basic requirements in any developing region are a reliable electric power grid, network infrastructure, education, jobs, and a stable government and banking system.

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With the growth of high speed networks over the last decades, there is an alarming rise in its usage comprised of thousands of concurrent e-commerce transactions and millions of Web queries a day. This ever-increasing demand is handled through large-scale datacenters, which consolidate hundreds and thousands of servers with other infrastructure such as cooling, storage and network systems. Many internet companies such as Google, Amazon, eBay, and Yahoo are operating such huge datacenters around the world. Traditionally, business organizations used to invest huge amount of capital and time in acquisition and maintenance of computational resources.

The emergence of Cloud computing is rapidly changing this *ownership-based* approach to *subscription-oriented* approach by providing access to scalable infrastructure and services on-demand. Moreover, Cloud computing also offers enormous amount of compute power to organizations which require processing of tremendous amount of data generated almost every day.

Cloud Computing provides an appropriate pool of computing resources with its dynamic scalability and usage of virtualized resources as a service through the Internet [Poonam, 2014]. The resources can be network servers, applications, platforms, infrastructure segments and services. It delivers services autonomously based on demand and provides sufficient network access, data resource environment and effectual flexibility. This technology is used for more efficient and cost effective computing by centralizing storage, memory, computing capacity of PC's and servers.

Cloud computing is a highly scalable and cost-effective infrastructure for running High Performance Computing (HPC), enterprise and Web applications [Ashish, 2013]. However, the growing demand of Cloud infrastructure has drastically increased the energy consumption of data centers, which has become a critical issue. The use of large shared virtualized datacenters, Cloud Computing can offer large energy savings. Also, the Cloud services can also further increase the internet traffic and its growing information database which could decrease such energy savings [Kamble 2013].

Cloud uses thousands of data-centers in order to process the user queries and to run these data-centers bulk amount of power is used for cooling and other processes. Every year this power consumption is gradually increasing and green cloud computing endeavors to reduce the same thus playing a helpful role to curb these issues. One area of research focuses on reduction in energy consumption and reduce the total power consumption by balancing load and effectively utilizing only a subset of the resources at hand. Some form of load balancing to save power during different load conditions. Many techniques are used to measure the power consumption in data-centers.

Many articles are been released on how Cloud Computing helps the developing world by just lowering ICT costs but, here it introduces Green computing aiming to reduce energy cost and CO_2 emissions as well as to effectively reuse and recycle power usage making the world *go-green*. Green computing is the environmentally responsible use of computers and related resources (Kaur 2014).

The approaches to Green Computing on Educational Institutions are power management, e-mail, on-line learning and energy/cost saving measures. Many institutions have chosen to include information on their websites about green computing efforts and how to reduce carbon footprints. Hence, energy efficient solutions are required to ensure the environmental sustainability of this new computing paradigm.

Green Cloud computing is envisioned to achieve not only efficient processing and utilization of computing infrastructure, but also minimize energy consumption [Gaganjot 2013]. Cloud computing with increasingly pervasive front-end client devices interacting with back-end data centers will cause an enormous escalation of energy usage. To address this problem, data center resources need to be managed in an energy-efficient manner to drive Green Cloud computing.