A Cloud-Oriented Green Computing Architecture for E-Learning Applications

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Abstract: Cloud computing is a highly scalable and cost-effective infrastructure for running Web applications. E-learning or e-Learning is one of such Web application has increasingly gained popularity in the recent years, as a comprehensive medium of global education system/training systems. The development of e-Learning Application within the cloud computing environment enables users to access diverse software applications, share data, collaborate more easily, and keep their data safely in the infrastructure. However, the growing demand of Cloud infrastructure has drastically increased the energy consumption of data centers, which has become a critical issue. High energy consumption not only translates to high operational cost, which reduces the profit margin of Cloud providers, but also leads to high carbon emissions which is not environmentally friendly. Hence, energy-efficient solutions are required to minimize the impact of Cloud-Oriented E-Learning on the environment. E-learning methods have drastically changed the educational environment and also reduced the use of papers and ultimately reduce the production of carbon footprint. E-learning methodology is an example of Green computing. Thus, in this paper, it is proposed a Cloud-Oriented Green Computing Architecture for eLearning Applications (COGALA). The e-Learning Applications using COGALA can lower expenses, reduce energy consumption, and help organizations with limited IT resources to deploy and maintain needed software in a timely manner. This paper also discussed the implication of this solution for future research directions to enable Cloud-Oriented Green Computing.

Keywords: *Cloud Computing, Green Computing, Green Cloud, E-learning, Data Centers, Energy Efficiency*

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I. INTRODUCTION

Cloud Computing is a new paradigm that 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. Cloud computing deliver 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. With the tremendous advantages of cloud computing, this technology is revolutionized the field of e-learning education.

The educational cloud computing [Anjali (2013)] can focus the power of thousands of computers on one problem, allowing researchers search and find models and make discoveries faster than ever. The Educational Institutions can also open their technology infrastructures to private, public sectors for research advancements. The role of cloud computing at Educational Institutions should not be underestimated as it can provide important gains in offering direct access to a wide range of different academic resources, research applications and educational tools. The architecture of an e-learning system [Palanivel (2014)] developed as a distributed application, includes a client application, an application server and a database server, beside the hardware to support it (client computer, communication infrastructure and servers).

Cloud computing is a highly scalable and cost-effective infrastructure for running 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. 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. 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)].

Green computing is the environmentally responsible use of computers and related resources (Kaur (2014). Such practices include the implementation of energy-efficient Central Processing Units (CPUs), servers and peripherals as well as reduced resource consumption and proper disposal of electronic waste (e-waste). 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 Cloud-Oriented Green computing.

The energy efficiency of ICT has become a major issue with the growing demand of Cloud Computing. Hence, the objective of this paper to propose a Cloud-Oriented Green Computing Architecture for e-Learning Applications (COGALA). The COGALA Architecture for reducing the carbon footprint of Cloud Computing in a wholesome manner without sacrificing the Quality such as performance, responsiveness and availability offered by multiple Cloud providers. The COGALA consists of the client (e.g. can be an University or an Educational Institution), a client-oriented green cloud middleware and the green broker. The green cloud middleware provide the client a tool to better manage the distribution of tasks to cloud with the least carbon emission (i.e. least power consumption) and other relevant decision criteria. The middleware is composed of a user interface application and a windows service. This architecture is designed such that it provides incentives to both users and providers to utilize and deliver the most "Green" services respectively. Also, it addresses the environmental problem from the overall usage of Cloud Computing resources.

This article is organized as follows: Section 2 introduces about various technical details that required to write this paper. Section 3 surveyed various architectures such as service-oriented, cloud-oriented and Green-Oriented. The proposed architecture is depicted in section 4 and finally section 5 concludes this paper.

II. BACKGROUND TECHNOLOGY

This section introduces Cloud Computing and its deployment/service models, impact of E-learning Cloud Computing, Cloud Computing and energy usage, various energy efficiency models and finally Green Computing in e-Learning applications.

A. Cloud Computing

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [Peter (2011)]. The characteristics of Clouds include on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service.

The available service models are classified as Software-as-a-Service (SaaS), Platform-as-a-Service(PaaS), and Infrastructure-as-a-Service (IaaS).

- Infrastructure as a Service (IaaS): IaaS is the supply of Hardware as a service (HaaS), that is, servers, net technology, storage or computation, as well as basic characteristics such as Operating Systems and virtualization of hardware resources [Hurwitz 2010]. Making an analogy with a monocomputer system, the IaaS will correspond to the hardware of such a computer together with the Operating System that take care of the management of the hardware resources and ease the access to them.
- Platform as a Service (PaaS): At the PaaS level, the provider supplies more than just infrastructure, i.e. an integrated set of software with all the stuff that a developer needs to build applications, both for the developing and for the execution stages. In this manner, a PaaS provider does not provide the infrastructure directly, but making use of the services of an IaaS it presents the tools that a developer needs, having an indirect access to the IaaS services and, consequently, to the infrastructure [Hurwitz 2010].
- Software as a Service (SaaS): In the last level we may find the SaaS, i.e. to offer software as a service. It has its origins in the host operations carried out by the Application Service Provider.

Cloud computing is offering on-demand services to end users. Clouds are deployed on physical infrastructure where Cloud middleware is implemented for delivering service to customers. Such an infrastructure and middleware differ in their services, administrative domain and access to users. Therefore, the Cloud deployments are classified mainly into three types: Public Cloud, Private Cloud and Hybrid Cloud.

- Public Clouds - Public Cloud is the most common deployment model where services are available to anyone on Internet. Some of the famous public Clouds are Amazon Web Services (AWS), Google AppEngine, and Microsoft Azure. Public Cloud offers very good solutions to the customers having small enterprise or with infrequent infrastructure usage, since these Clouds provide a very good option to handle peak loads on the local infrastructure and for an effective capacity planning.

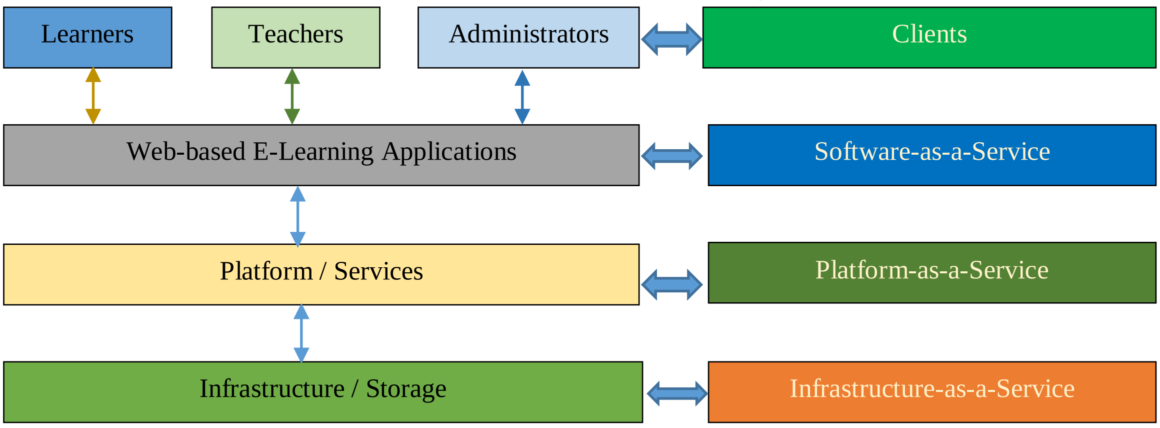

Figure 1: Cloud-Oriented E-Learning Architecture

- Private Clouds - The private Clouds are deployed within the premise of an organization to provide IT services to its internal users. The private Cloud services offer greater control over the infrastructure, improving security and service resilience because its access is restricted to one or few organizations. Such private deployment poses an inherent limitation to end user applications i.e. inability to scale elastically on demand as can be done using pubic Cloud services.
- Hybrid Clouds - Hybrid Clouds is the deployment which emerged due to diffusion of both public and private Clouds‟ advantages. In this model, organizations outsource non-critical information and processing to the public Cloud, while keeping critical services and data in their control.
- The Community Cloud - In the community deployment model, the cloud infrastructure is shared by several organizations with the same policy and compliance considerations. This helps to further reduce costs as compared to a private cloud, as it is shared by larger group.

B. Cloud-Oriented e-Learning

Cloud computing has a significant impact on teaching and learning environment [Fern (2012)]. It is highly practical in education for both students and teachers. The cloud based environment supports the creation of new generation of e-learning systems. In traditional web-based learning model, educational institutions invest a huge amount of money on hardware and software applications, infrastructure, maintenance and the appropriate training of staff to enable them to use technology effectively. However, in cloud based e-learning model, educational institutions without any infrastructure investments can get powerful software with lower or no up-front costs and fewer management headaches in the classroom. The development of e-Learning services within the cloud computing environment enables users to access diverse software applications, share data, collaborate more easily, and keep their data safely in the infrastructure. Moreover, it can lower expenses, reduce energy consumption, and help organizations with limited IT resources to deploy and maintain needed software in a timely manner.

Figure 1 shows architecture for e-learning system that the cloud-oriented architecture [Manop (2012)] separate into three layers includes infrastructure, platform and application. On Infrastructure layer, the learning resources from the traditional system are transferred to the cloud database instead of the usual DBMS. Whereas on Platform layer, a new e-learning system that consists of the CMS, AMS, and other service components were developed. These components were developed to be the intermediary between cloud database and the applications. Finally on application layer, web application were developed for interacting with the student's client. As the adoption of cloud computing increases, many academic institutions are introducing cloud computing technologies into their education systems, promising and delivering more scalable and reliable education services.

Many Educational Institutions have acknowledged the potential benefits of leveraging cloud computing for economic reasons, as well as for more advanced teaching and data sharing [Mircea (2011)]. A number of studies were conducted to investigate the benefits of using cloud computing for e-Learning systems [Pocatilu (2009), Pocatilu (2010), Bora (2013)] and to suggest solutions for cloud computing-based e-learning systems [Masud (2012), Masud (2012), Bora (2013), Zoube (2010)].

Pocatilu (2010) presented cloud computing advantages for e-Learning as being low cost with higher data security, virtualization, centralized data storage, and the possibility of monitoring data access. There are numerous advantages when the e-learning is implemented with the cloud computing technology, they are low cost, improved performance, instant software update, Improved document format compatibility, Benefits for students and teachers, data security, etc.

C. e-Learning Data Centers

Figure 2 shows an end user accessing Cloud services such as SaaS, PaaS, or IaaS over Internet. User data pass from his own device through an Internet service providers' router, which in turn connects to a Gateway router within a Cloud datacenter. Within datacenters, data goes through a local area network and are processed on virtual machines, hosting Cloud services, which may access storage servers. Each of these computing and network devices that are directly accessed to serve Cloud users contribute to energy consumption. In addition, within a Cloud datacenter, there are many other devices, such as cooling and electrical devices, that consume power. These devices even though do not directly help in providing Cloud service, are the major contributors to the power consumption of a Cloud datacenter.

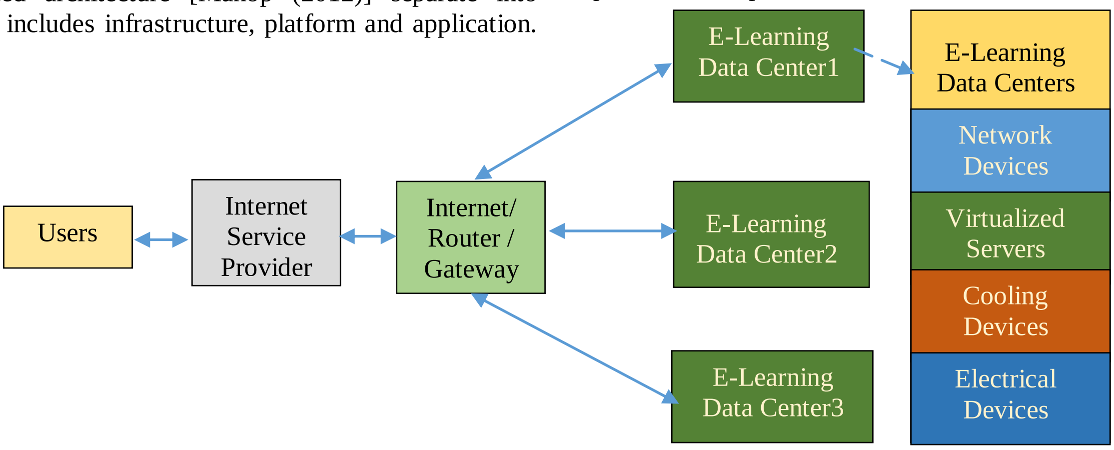

Figure 2: Usage Model of Cloud-Oriented e-Learning

User/Cloud Software Applications - The Cloud computing can be used for running **e-Learning** applications owned by individual user or offered by the Cloud provider using SaaS. Here, e-Learning applications are long running with high CPU and memory requirements then its execution will result in high energy consumption. Thus, energy consumption will be directly proportional to the e-Learning application's profile **which** will result in much higher energy consumption than actually required.

Cloud Software Stack - The Cloud software stack leads to an extra overhead in execution of end user **or learners** applications. For instance, it is well known that a physical e-Learning applications server has higher performance efficiency than a virtual machine and IaaS providers offer generally access to a virtual machine to its end users [Cherkasova (2005)].

Network Devices - In Cloud computing, since resources are accessed through Internet, both applications and data are needed to be transferred to the compute node. In e-Learning applications, if data is really large, then it may turn out to be cheaper and more carbon emission efficient to send the data by mail than to transfer through Internet. **T**he energy consumption of these devices remains almost the same during both peak time and idle state.

Datacenter - A cloud datacenter could comprise of many hundreds or thousands of networked computers with their corresponding storage and networking subsystems, power distribution and conditioning equipment, and cooling infrastructures. These datacenters can consume massive energy consumption and emit large amount of carbon. Thus, to achieve the maximum efficiency in power consumption and CO_2 emissions, each of these devices need to be designed and used efficiently while ensuring that their carbon footprint is reduced. Power Usage Effectiveness (PUE) [Rawson (2008)] is a key factor in achieving the reduction in power consumption of a datacenter is to calculate how much energy is consumed in cooling and other overheads. PUE of datacenter can be useful in measuring power efficiency of datacenters and thus provide a motivation to improve its efficiency.

D. Cloud Computing Energy Usage Model

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. It offers enormous amount of compute power to organizations which require processing of tremendous amount of data generated almost every day. The Cloud Computing model is for where the data is to be distributed, so that knowledge resources will be used by all sorts of user in the education streams. Clouds are essentially virtualized datacenters and applications offered as services on a subscription basis. They require high energy usage for its operation [Bianchini (2004)]. For a datacenter, the energy cost is a significant component of its operating and up-front costs. Thus, energy consumption and carbon emission by Cloud infrastructures has become a key environmental concern.

The traditional data centers running Web applications are often provisioned to handle sporadic peak loads, which can result in low resource utilization and wastage of energy. Cloud datacenter, on the other hand, can reduce the energy consumed through server consolidation, whereby different workloads can share the same physical host using virtualization and unused servers can be switched off. Even the most efficiently built datacenter with the highest utilization rates will only mitigate, rather than eliminate, harmful CO_2 emissions. The reason given is that Cloud providers are more interested in electricity cost reduction rather than carbon emission. The Figure 3 shows that cloud and environmental sustainability.

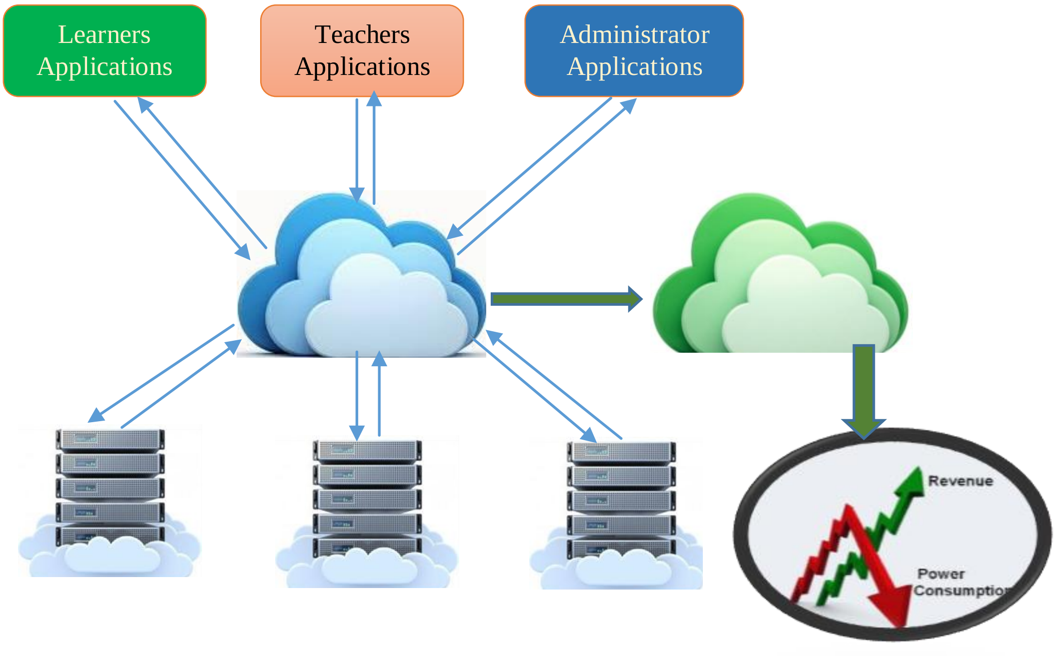

Figure 3: Cloud and Environmental Sustainability.

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E. Cloud-Oriented Green Computing

E-learning methods have drastically changed the educational environment and also reduced the use of papers and ultimately reduce the production of carbon footprint. E-learning methodology is an example of Green computing. Cloud –Oriented Green Computing points to a processing infrastructure that combines flexibility, service quality, and reduced use of energy. Energy crisis fuels green computing, and green computing needs algorithms and mechanisms to be redesigned for energy efficiency. There is a need to use computing resources efficiently, effectively and economically. The various approaches to green information technology are *virtualization*, *power management*, *Materials Recycling* and *Telecommuting*. It is necessary to significantly reduce pollution and substantially lower power consumption.

The technology for energy efficient Clouds is “Virtualization,” which allows significant improvement in energy efficiency of Cloud providers by leveraging the economies of scale associated with large number of organizations sharing the same infrastructure [Smith (2003)]. By consolidation of underutilized servers in the form of multiple virtual machines sharing same physical server at higher utilization, companies can gain high savings in the form of space, management, and energy.

F. Cloud-Oriented Green Computing Architecture

Cloud computing, being an emerging technology also raises significant questions about its environmental sustainability. Through the use of large shared virtualized datacenters Cloud computing can offer large energy savings. However, Cloud services can also further increase the internet traffic and its growing information database which could decrease such energy savings. With energy shortages and global climate, the power consumption of data centers has become a key issue. Thus, there is a need of green cloud computing solutions that cannot only save energy, but also reduce operational costs. The underlying *physical computing servers* provide hardware infrastructure for creating virtualized resources to meet service demands.

The key factors that have enabled the Cloud computing to lower energy usage and carbon emissions from ICT are ***dynamic provisioning***, ***multi-tenancy***, ***server utilization*** and ***data center*** efficiency [Accenture (2010)]. Due to these Cloud features, organizations can reduce carbon emissions by moving their applications to the Cloud. These savings are driven by the high efficiency of large scale Cloud data centers. Improving the resource utilization and reduce power consumption are key challenges to the success of operating a cloud computing environment. To address such challenges, it is proposed to design the Green - Cloud architecture for data center such e-Learning.

The Figure 4 shows the Cloud-Oriented Green Computing Architecture. In Green -Cloud computing infrastructure, there are four main entities involved and they are Consumers/Brokers, Green Resource Allocator, Virtual Machines (VMs) and Physical Machines.

- The *Cloud consumers* or their brokers submit service requests from anywhere in the world to the Cloud. It is important to notice that there can be a difference between Cloud consumers and users of deployed services.
- The *Green Resource Allocator* acts as the interface between the Cloud infrastructure and consumers. It requires the interaction of the following components to support energy-efficient resource management.

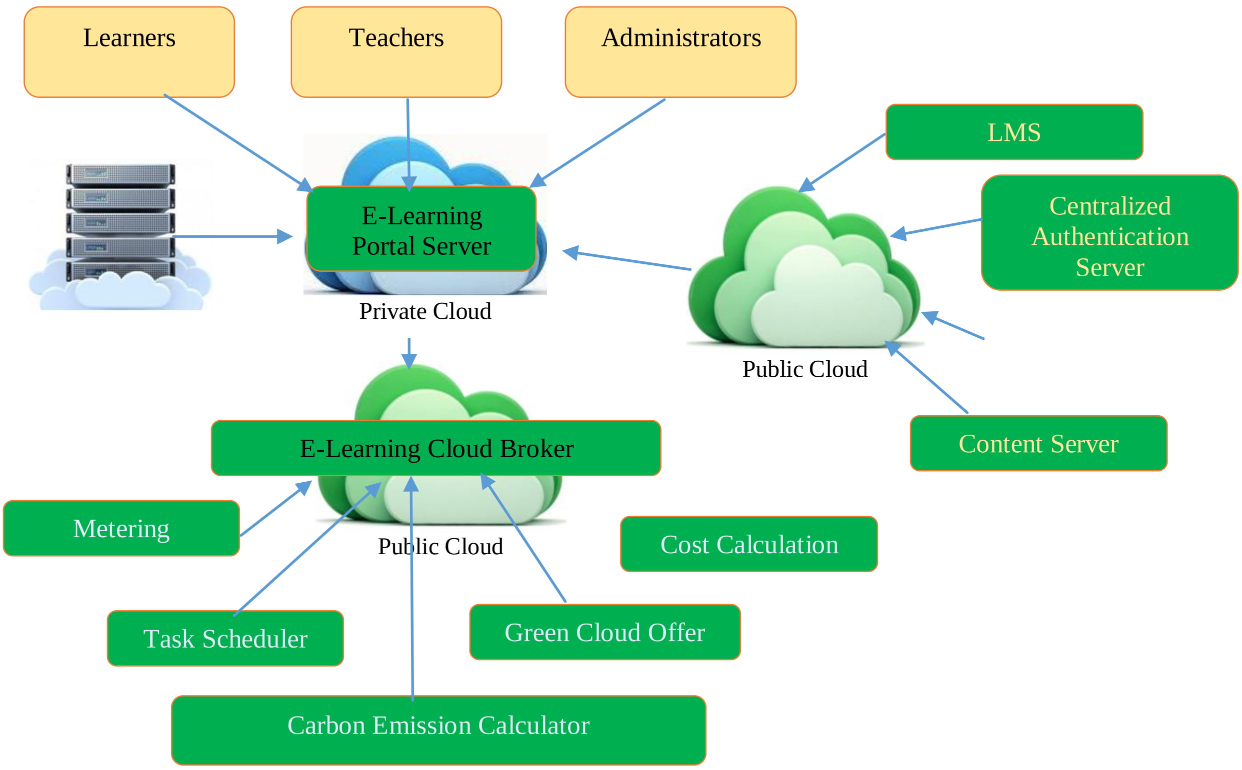

Figure 4: *Cloud-Oriented Cloud Computing Architecture*

- Multiple *Virtual Machines* (VMs) can be dynamically started and stopped on a single physical machine to meet accepted requests, hence providing maximum flexibility to configure various partitions of resources on the same physical machine to different specific requirements of service requests. Multiple VMs can also concurrently run applications based on different operating system environments on a single physical machine.

The objective of this paper is to design a Cloud-Oriented Green Computing Architecture for e-Learning Applications. Hence, it is proposed to review existing works in the area of architecture of Cloud Computing, Green Computing and both.

III. SURVEY AND RELATED WORKS

This section review existing works in the area of Cloud Computing architecture and Green Computing architecture and energy efficiency.

Service Oriented Cloud Computing Architecture (Lohm 2013) is used to transfer E-learning into the cloud. These architectures cover challenges of e-learning such as scalability, application development, efficient use of resources, saving expense, and security.

Engin (2013) presented some possible cloud solutions in e-learning environments by emphasizing its pros and cons. It is of paramount importance to choose the most suitable cloud model for an e-learning application or an educational organization in terms of scalability, portability and security. We distinguish various deployment alternatives of cloud computing and discuss their benefits against typical e-learning requirements.

Developments in computing are influencing many aspects of education. The purpose Faten (2013) is to assess the potential value of cloud computing as a platform for e-learning. In particular, the paper will discuss how cloud computing is different from other forms of computing and what makes it unique. As well is this, the potential advantages and disadvantages of using cloud computing as a platform for e-learning will be outlined. Finally, the requirements of implementing cloud computing will be discussed, along with an assessment of the challenges to implementation, and some potential ways to overcome them.

Cloud computing has attracted a great deal of attention in the education sector as a way of delivering more economical, securable, and reliable education services. (Ji 2013) proposed and introduces a cloud-based smart education system for e-learning content services with a view to delivering and sharing various enhanced forms of educational content, including text, pictures, images, videos, 3-dimensional (3D) objects, and scenes of virtual reality (VR) and augmented reality (AR).

Tomm (2012) presented the real-time virtualized Cloud infrastructure that was developed in the context of the IRMOS European Project. The paper shows how different concepts, such as real-time scheduling, QoS-aware network protocols, and methodologies for stochastic modelling and run-time provisioning were practically combined to provide strong performance guarantees to soft real-time interactive applications in a Virtualized environment. The efficiency of the IRMOS Cloud is demonstrated by two real interactive e-Learning applications, an e-Learning mobile content delivery applications and a virtual world e-Learning applications.

Anwar (2012) introduced the characteristics of the current E-Learning and then analyses the concept of cloud computing and describes the architecture of cloud computing platform by combining the features of E-Learning. The authors have tried to introduce cloud computing to e-learning, build an e-learning cloud, and make an active research and exploration for it from the following aspects: architecture, construction method and external interface with the model.

Green Computing or Green IT refers to the study and practice of using computing resources in an eco-friendly manner in order to tone down the environmental impacts of computing. It is the practice of using computing resources in an energy efficient and environmentally friendly manner. Shalabh (2013) discussed how Green Computing can be incorporated into different institutions, corporate/business sectors or may be in various IT companies.

To reduce unnecessary energy consumption due to hazardous materials has become a major topic of concern today.

IV. PROPOOSED ARCHITECTURE - COGALA

As new distributed computing technologies like Clouds become increasingly popular, the dependence on power also increases. The majority of the energy used in today's society is generated from fossil fuels which produce harmful CO_2 emissions. Therefore, it is imperative to enhance the efficiency and potential sustainability of large data centers. Therefore, there is a need to create an efficient Cloud computing system that utilizes the strengths of the Cloud while minimizing its energy and environmental footprint. In order to correctly and completely unify a Green aspect to the next generation of Distributed Systems, a green-oriented architecture is needed. Challenges in Cloud-Oriented E-Learning

With the huge growth of the number of students, education contents, services that can be offered and resources made available, e-Learning system dimensions grow at an exponential rate. The challenges regarding this topic about optimizing resource computation, storage and communication requirements, energy efficiency and dealing with dynamic concurrency requests highlight the necessity of the use of a platform that meets scalable demands and cost control.

From the above study of current efforts in making Cloud computing energy efficient, it shows that even though researchers have made various components of Cloud efficient in terms of power and performance, still they lack a unified picture. Cloud providers, being profit oriented, are looking for solutions which can reduce the power consumption and thus, carbon emission without hurting their market. Therefore, it is provided provide a unified solution to enable e-Learning using Green Cloud Computing.

A. COGALA Architecture

The COGALA architecture can be divided into the following layers:

- *Infrastructure layer* as a dynamic and scalable physical host pool, *software resource layer* that offers a unified interface for e-learning developers, *resource management layer* that achieves loose coupling of

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software and hardware resources, *service layer*, containing three levels of services (software as a service, platform as a service and infrastructure as a service), *application layer* that provides with content production, content delivery, virtual laboratory, collaborative learning, assessment and management features.

- *Infrastructure layer* is composed of information infrastructure and teaching resources. Information infrastructure contains Internet/Intranet, system software, information management system and some common software and hardware; teaching resources is accumulated mainly in traditional teaching model and distributed in different departments and domain. This layer is located in the lowest level of cloud service middleware, the basic computing power like physical memory, CPU, memory is provided by the layer. Through the use of virtualization technology, physical server, storage and network form virtualization group for being called by upper software platform. The physical host pool is dynamic and scalable, new physical host can be added in order to enhance physical computing power for cloud middleware services
- *Software Resource Layer* mainly is composed by operating system and middleware. Through middleware technology, a variety of software resources are integrated to provide a unified interface for software developers, so they can easily develop a lot of applications based on software resources and embed them in the cloud, making them available for cloud computing users.
- *Resource Management Layer* is the key to achieve loose coupling of software resources and hardware resources. Through integration of virtualization and cloud computing scheduling strategy, on-demand free flow and distribution of software over various hardware resources can be achieved.
- *Service layer* has three levels of services namely, SaaS (Software as a service), Paas (Platform as a service), IaaS (Infrastructure as a service). In SaaS, cloud computing service is provided to customers. As is different from traditional software, users use software via the Internet, not to need a one-time purchase for software and hardware, and not to need to maintain and upgrade, simply paying a monthly fee.
- *Application layer* is the specific application of integration the teaching resources in the cloud computing model, including interactive courses and sharing the teaching resources. The interactive programs are mainly for the teachers, according to the learners and teaching needs, taken full advantage of the underlying information resources after finishing made, and the course content as well as the progress may at any time adjust according to the feedback, and can be more effectiveness than traditional teaching. Sharing of teaching resources include teaching material resources, teaching information resources (such as digital libraries, information centers), as well as the full sharing of human resources. This layer mainly consists of content production, educational objectives, content delivery technology, assessment and management component.

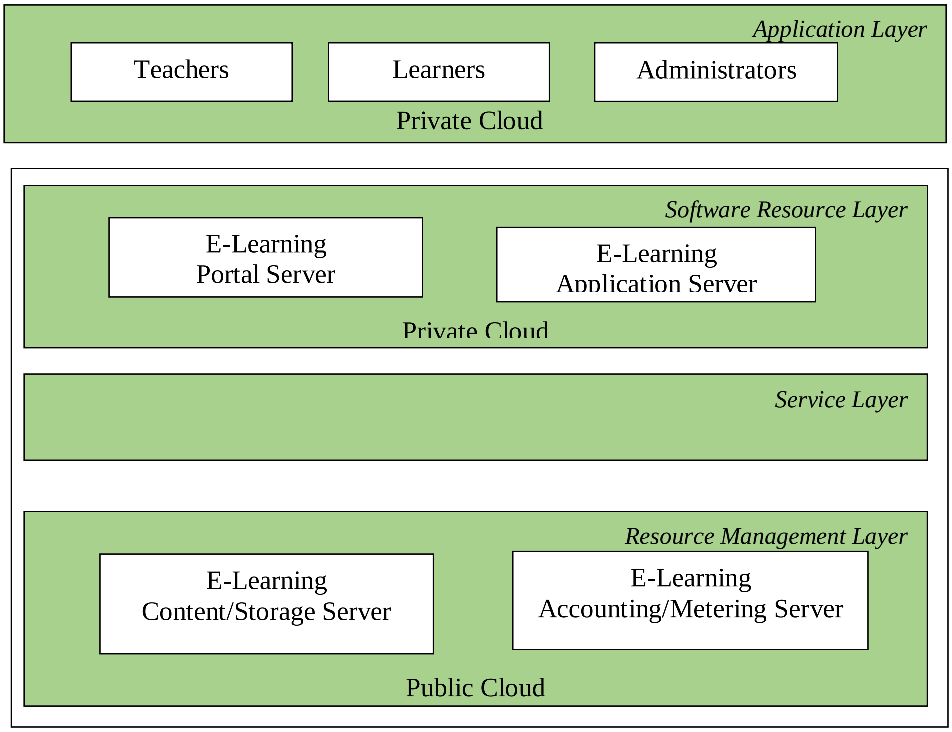

Figure 5*: Cloud-Oriented Green Computing Architecture for E-Learning*

A. How COGALA Works?

In the COGALA architecture, learners/teachers submit their Cloud service requests through a new middleware Green Broker that manages the selection of the greenest Cloud provider to serve the user's request. A learner/teacher service request can be of three types i.e., software, platform or infrastructure. The Cloud providers can register their services in the form of green offers" to a public directory which is accessed by Green Broker. The green offers consist of green services, pricing and time when it should be accessed for least carbon emission. Green Broker gets the current status of energy parameters for using various Cloud services from Carbon Emission Directory.

The Carbon Emission Directory maintains all the data related to energy efficiency of Cloud service. This data may include PUE and cooling efficiency of Cloud datacenter which is providing the service, the network cost and carbon emission rate of electricity, Green Broker calculates the carbon emission of all the Cloud providers who are offering the requested Cloud service. Then, it selects the set of services that will result in least carbon emission and buy these services on behalf users.

The COGALA architecture is designed such that it keeps track of overall energy usage of serving a user request. It relies on two main components, Carbon Emission and Green Cloud offers, which keep track of energy efficiency of each Cloud provider and also give incentive to Cloud providers to make their service "Green". From user side, the Green Broker plays a crucial role in monitoring and selecting the Cloud services based on the user QoS requirements, and ensuring minimum carbon emission for serving a user. In general, a user can use Cloud to access any of these three types of services (SaaS, PaaS, and IaaS), and therefore process of serving them should also be energy efficient.

Cloud Computing use latest technologies for IT and cooling systems to have most energy efficient infrastructure. By using virtualization and consolidation, the energy consumption is further reduced by switching-off unutilized server. Various energy meters and sensors are installed and calculated the current energy efficiency of each service providers.

B. Energy Consumption

To measure the unified efficiency of a datacenter and improve its' performance per-watt, the Green Grid has proposed two specific metrics known as the Power Usage Effectiveness (PUE) and Datacenter Infrastructure Efficiency (DciE) .

PUE = Total Facility Power/IT Equipment Power

DciE = 1/PUE = IT Equipment Power/Total Facility Power x 100%

The Total Facility Power is defined as the power measured at the utility meter that is dedicated solely to the datacenter power. The IT Equipment Power is defined as the power consumed in the management, processing, and storage or routing of data within the datacenter.

The expected benefits for which planned to implement COGALA are environment friendly, efficient and time saving.

V. Conclusions and Future Directions

In this paper, it analyzed the benefits offered by Cloud computing by studying its fundamental definitions and benefits, the services it offers to end users, and its deployment model. E-learning system is facing challenges of optimizing large-scale resource management and provisioning, according to the huge growth of users, services, education contents and media resources. We have settle the goodness of a Cloud Computing solution. The features of the Cloud Computing platform are quite appropriate for the migration of this learning system, so that we can fully exploit the possibilities offered by the creation of an efficient learning environment that offers personalized contents and easy adaptation to the current education model. Then, it discussed the components of Clouds that contribute to carbon emission and the features of Clouds that make it "Green". Even though the proposed Cloud-Oriented Green Architecture embeds various features to make Cloud computing much more Green, there are still many technological solutions are required to make it a reality.

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