Load Balance Optimization for Cloud-based E-Learning Environment

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Abstract - In present scenario, the prodigious augmentation of internet broadband services, rich education content and affordable computers has led to the creation of global phenomenon that elevates the education standard. Due to the dynamic scalability and usage of virtualized resources, cloud computing provides a significant impact on the educational environment. With that consideration, this paper presents an E-learning system incorporating with cloud computing technology. Along with all advancements and services of cloud, the proposal endeavors to incorporate an adept methodology for Learning as a Service (Laas). Mostly, the work is focused on load forecasting and content management with the inclusion of memory optimization algorithm in order to bring out an efficient e-learning environment to the novices in a cloud. Moreover, session tracking methods are invoked for enhancing the intelligence of the e-learning systems. Experimentation has been done by determining the parameters such as, QoS, memory usage and processing time for substantiating the potency of the adduced work.

Index Terms-E-Learning, Cloud computing, virtual machine, loads forecasting, content management.

I. INTRODUCTION

Progressive popularity and interests of learning through internet emanates a need of an efficacious web-based learning environment. While analyzing in that manner, the conventional modes of web-based E-Learning are found to be insufficient to attain the requirements of educational proliferation, social progress and to adapt with the dynamic learning demands. Moreover, there are some limitations in such learning modes in the aspects such as system construction, maintenance, etc. The development of cloud computing architecture by embedding the e-learning features, affords a valid solution for the aforementioned hindrances.

As is well-known, in recent years, cloud computing accelerates the distinctive innovations for the computer industry. Furthermore, as with massive growth of cloud computing framework usage, several industries converge on to renting the processing power from a specialized vendors rather than investing into it. In order to adopt the eminent features of cloud computing such as, reduced upfront investment, reduced launching time, expected performance, high availability, infinite scalability, enhanced collaboration, accessibility and mobility, it is invoked in e-learning patterns. Basically, cloud computing is an assortment of servers delivering resources, which can be remotely accessed through internet in real-time. The technology becomes more attractive since it provides dynamic scalability and effective resource utilization, where there is limited resource availability. Hence, both in academia and industry, cloud computing has been attained significant attention and momentum.

In past decade, grid computing was coined to allow consumers to acquire processing power on demand. Subsequently, researchers tried to extend the grid techniques to afford more on demand services to the users. Thus, the concepts of grid hardly resembles in cloud, where both needs to manage large facilities and have to define methods for consumer's request and resource usage. The commonality between cloud and grid occurs in vision, architecture and technology, and the conceits highly differ in aspects such as, security, computation model, applications and abstractions [14].
The motive of grid computing architecture is to resolve large tasks by using the pros of parallelism and concurrency concepts, whereas the cloud computing confers attention on relationship. Cloud computing becomes very trendy because it converts the processing efforts from the local devices in the network to the data center facilities. Therefore, any device can be able to solve difficult queries by simply throwing the arguments to the service, which is running at the data center level and gives back the results within a very small instant. The cloud computing attributes that outperforms the traditional computing are revealed in the Figure 1.

The various cloud computing services are [2]:

**IaaS (Infrastructure as a Service):**
With IaaS, the components of infrastructure layer such as computation power and storage resources can be rented from the virtual resource pool for the entire industry.

**PaaS (Platform as a Service):**
This corresponds to platform layer that made the higher level of abstraction with IaaS base. This affords services for developing, and testing server platforms and other related services.

**SaaS (Software as a Service):**
SaaS is stated as a software distribution model, which can be accessed by the user through the internet hosting. It is necessary that the Figure 1. Traditional Computing Vs Cloud Computing providers have to develop information for all infrastructures and software oriented activities. It is also important to offer post-maintenance and other services.

On the other hand, E-learning is widely used on diverse educational levels such as continuous education, corporate training, academic courses, etc. There are assorted e-learning solutions from open source to commercial. Due to the improved improbability, virtualization and centralized data storage, the cloud computing technology has a profound impact in e-learning process and that service is explicitly termed as Learning as a Service (LaaS).

With those eminences of cloud computing technology, this paper concentrates on developing an E-Learning Framework that combines extensive range of technology and tools for education. The affirmed environment is intended to bring up formal and informal endless learning, and to facilitate mashup of distinctive applications and learning services.

The generic e-learning in cloud shares various infrastructure resources and bridges the huge system pool together to furnish the required services. Cloud computing accedes the network layer to execute more like the internet and make the hardware resources to be shared and accessed as data sources in scalable and secured way. Load forecasting plays a significant role in this system development process, by which the optimal virtual machine could be selected for effective learning process. Specifically, content management and session tracking techniques are incorporated in order to provide evident for the intelligence of adduced work. Moreover, the established framework will be quite enough to validate the learner activities.
The paper is organized as follows. Section 2 provides a deliberation on the related work. In Section 3 the system architecture is presented with design implementation of the affirmed system. Section 4 presents the experimental results and Section 5 concludes the paper and discusses about the future work.

II. RELATED WORKS

Proliferation of internet as a global platform for education requires efficient load balancing, scheduling and content management mechanisms, which paves way to produce engrossing research work. Solution architecture was presented with dependability aspects such as availability, scalability, usability, stability, interoperability, security of software and hardware components for developing an e-learning system in [3]. There are some described methods for monitoring the underlying services and about Network Management Software (NMS), which is based on service polling, data collection and event & notification management. Following that, e-learning system on cloud was given in [12, 10]. It provided a cloud computing based solution for developing a virtual and personal learning environment that amalgamates wide range of technology and tools. The environment was intended for monitoring educational content along with platform creation for exploring ideas. This invoked smart agents for specifically addressing the learning needs for the novices based on their prior knowledge.

Adversely, an agile e-learning information system was given in [17]. The system comprised adaptable, reusable and changeable content. There used web ontology language (OWL) for the retrieval of information that solves context problem. The paper mainly concentrated on presenting static learning content. Description about measuring the efficiency of cloud computing in e-learning systems was given in [6]. The authors developed a metrics system for efficiency measurement. Pareto principle had been used for quality control evaluation. The e-learning systems use cloud computing, by which the required resources could be adjusted as needed [9]. Furthermore, the benefits of cloud computing technology for e-learning solutions were provided with improved interoperability, with virtualization, by managing centralized data storage and facile data monitoring capability. Besides, the above works were not concentrating on load balancing and scheduling mechanisms for adept e-learning. In order to cope with workload fluctuations and maintain a good quality of service, a system administrator must provision enough resources. On that note, the paper [4] presented elastic system architecture for dynamic resource management and optimization in virtualized environment. The controllers at CPU, memory and application run parallel affords for efficient resource allocation and optimized performance on virtual machines dynamically. In [15], an algorithm was demonstrated based on exponential smoothing (ES) for monitoring and managing the machines of technological infrastructure. Moreover, the methodology had been framed to perform cloud provisioning based on CPU utilization without any consideration of memory usage of the virtual machines.

The work explained in [19] stated the blended learning concept based on cloud computing paradigm. Because of cloud implementation, a new learning environment could be framed by the e-learning service providers to support extensive learning capabilities. Present economic situation forces the organizations to adopt a cloud solution. The implementation of cloud solution significantly decreases the expenses [1]. The authors introduced an e-learning cloud architecture, construction model and external interface with the model. The architecture composed of the following layers.

- Infrastructure Layer
- Software resource Layer
- Resource Management Layer
- Service Layer
- Application Layer

One of the ultimate goals of cloud computing service providers is to gain maximum profits with efficient load forecasting algorithms. With that aspect, different Virtual Machine (VM) load balancing algorithms are analyzed and incorporated in VM environment of cloud computing for providing better response time and reduced time [5]. For that purpose, modified throttled load balancing algorithm was implemented that increases the overall performance of cloud environment in e-learning process. There was a discussion on the issues and benefits of cloud computing in modern
education in [7]. The e-learning cloud computing business model given in that paper consists of e-learning cloud, cloud users and cloud providers. Inception of cloud computing into e-learning brings infinite computing capability, improved scalability and advancements.

Methods for managing e-learning using clouds were given in [8], where the cloud computing concepts are analyzed. Analysis also made with the compatibility of MOODLE (Modular Object-Oriented Dynamic Learning Environment) in order to provide optimized educational collaboration. A different approach named multi layered semantic Learning Object Metadata (LOM) framework that integrated semantic web into LOM [11]. The work supported knowledge representation for acquiring relevant learning object during the e-learning process. In [13], the methodology provided guidelines for Small and Medium Enterprises (SME) to incorporate cloud computing services in association with the trans-theoretical model. Since cloud computing involves in facilitating reduced costs of accessing and effective management of e-learning technologies, strategies and contents. The authors of [16] derived a conceptual model of distributed learning management systems by employing cloud computing techniques along with web services. The paper utterly focused on applying specific technologies that supports education for instance, cost reduction and lower maintenance.

Web-based education environment is one of the hot points on researching remote education. The proposal [18] developed architecture on cloud computing platform by combining the e-learning features based on different cloud computing types namely, public cloud, private cloud a hybrid cloud. The potentials and development methods of cloud based education framework in STEM fields was discussed in [20]. Three pilot conceits namely database, operating system and parallel computing on variant public clouds were examined and the usefulness of the framework was explained.

Considering the works stated above, it is conspicuous that the memory optimization, load forecasting and content management are not focused more in creating efficient e-learning environment in most approaches, even those have significant impact on web-based learning. Nevertheless, analyzing those pedagogical works, the proposed work invokes cloud computing technology that can be exploited to develop the next generation of platform independent and measurable data storage learning system to proffer smart formal and e-learning environment.

III. PROPOSED WORK

Cloud based e-learning is the subsidiary of cloud computing that is employed and noted as the future on educational field of e-learning systems and its infrastructures. As stated earlier, e-learning integrated with cloud has all the provisions such as hardware and software computing resources to amend the traditional e-learning infrastructures and functionalities. Those computing resources are virtualized and afforded in the form of services to the novices or clients. With that stimulation, the research work involves in framing an e-learning system using the cloud computing technology. In order to outperform the conceits of related works, we induce load forecasting, content management and memory optimization. Figure 2 shows the cloud based educational benefits of the proposed work. Hence, it is obvious that the e-learning system has benefits in three folds.

In this adduced work, a cloud environment is created with N number of Virtual Machines (VMs). Consequently, VM memory optimization algorithm is framed for adept load forecasting. Following that, QoS of corresponding VMs are analyzed and results an optimized virtual machine to the novice. The requested job or process is allocated to that optimized virtual machine and the e-learning process is carried out with that. In addition, Content management methods are incorporated along with session tracking that effectively tracks the most frequent sites and the user activities, and based on that the contents of the particular site could be modified for further references.

The administrator of the e-learning system works in the aspects of content management, resource management and security constraints. Moreover, QoS of VMs are determined by the matrices such as CPU processing time, memory usage, bandwidth consumption and application.
A. **Load Forecasting**

As stated above, the elementary phase of the research is to analyze the VMs for free memory computation. Moreover, it is the key issue in cloud computing for efficient resource provisioning. With that note, the CPU and memory usage of all the VMs in a cloud environment is computed by taking trend and seasonality into the account. Factualy, seasonality is defined as the tendency of time series data to exploit the demeanor that loops itself every T periods. The CPU and memory usage are termed as \( \Omega_n \) and \( \Gamma_n \) respectively. The computation is made with the following equations. Let N be the set of all virtual machines,

\[
\Omega_n = L_t + (T_t \cdot S_t) 
\]

where \( n \in N \) \hspace{1cm} (1)

\[
L_t = \alpha \cdot \frac{x_t}{S_t} + (1 - \alpha) \cdot (L_{t-1} + T_{t-1}) 
\]

\[
T_t = \beta \cdot (L_t - L_{t-1}) + (1 - \beta) \cdot T_{t-1} 
\]

\[
S_t = \gamma \cdot \frac{x_t}{L_t} + (1 - \gamma) \cdot S_{t-1} 
\]

\[
\Gamma_t = \text{Mem} (T_t \cdot S_t) 
\]

Where \( x_t \) being the observed value of time series at time \( t \), \( L_t \) is the deseasonalized level, \( T_t \) is the trend of the time series and \( S_t \) is the seasonal component. In the equations, \( \alpha, \beta, \gamma \) are the constants estimated to reduce the Mean Square Error (MSE) value. By applying the equations presented above in \( N \) set of virtual machines individually, the \( \Omega_n \) and \( \Gamma_n \) values are computed. The machine with minimal CPU and memory usage is considered to be the optimized VM having largest free memory. Load balancing is much significant for resource provisioning in cloud based e-learning environment that provides better utilization of resources and low power consumption.

B. **QoS Analysis**

Following the load forecasting, the quality of service analysis for all virtual machines in a cloud has been made to facilitate more optimized VM for a specific e-learning process. The QoS measure of each machine is computed by considering the following factors.

1. CPU usage
2. Physical memory usage
3. Bandwidth Consumption
The Virtual Machine Manager (VMM) of cloud environment is responsible for this computation. When a service level objective is given to a particular QoS analyzer, it hands over the task to resource monitor, CPU scheduler and memory manager in VMM to examine the performance of all the machines. The Figure 3 reveals the pictorial view of QoS analysis.

Memory manager is to conserve the system away from bottleneck problems. The resource monitor in VMM dynamically measures the resource consumption and amends the QoS value with new measurements. The CPU scheduler is enforced to perform dynamic CPU allocation of the VMs according to the determined values of QoS analyzer. Finally, the performance monitor computes the performances of VM, according to its average response time and throughput. The process results an optimal virtual machine for an effective e-learning process.

C. Job Deployment

Job deployment is the process of allocating particular request or process to a concern machine for further accomplishments. The process of job allocation to an optimal virtual machine has become more facile, by load forecasting computations and QoS analysis. In general, the request is received by the datacenter controller and then allocated to the VM, which is least loaded, provides lower response time and having large free memory. Moreover, with efficient algorithm, the information about the optimized VM that is assigned for serving a request is reported to the datacenter controller dynamically, where the allocation table is maintained. When the controller notifies the new allocation, it is automatically updated to the allocation table. The allocation count for that specific VM is increased in sense of assisting the remaining requests in queue and serving them with next optimized VM on the cloud. Once the VM finishes processing the request, it sends the response to the datacenter controller, from which the user receives required information. The updates make changes in allocation table at datacenter controller for further job assignments.

With various considerations regarding memory, processing time, CPU consumption, bandwidth consumption and response time, the job deployment is processed. Thus, the technique positively affects the e-learning environment to effectively serve the novices.

D. Content Management in E-Learning Environment

Content management plays a vital role in the proposed work. Persuasive content management is a substantial task for the administrator of an e-learning system. On that aspect, for managing content in an adept manner on the World Wide Web, tracking mechanism is incorporated. The proposal accomplishes session tracking mechanism for tracking the user activities and site registrations. By analyzing the session with user activities, the most visited sites and least visited sites are registered. According to these notifications, the content of the referred site is updated for further improvements and citations. The aforesaid process is summated with the following functionalities.

1. Learner Session Tracking
2. Learner Assessment
3. Decision Making
As framed, the e-learning environment greatly concentrates on content management. The contents of the web site are managed by tracking the learner activities and assessing the learner’s knowledge by an assessment test in order to predict their proficiency in that particular topic. And then, decision making about the content modification is performed to effectively update the contents and provide sufficient information to the novices.

Figure 4 depicts the overall flow of proposed method. As is well-known, security constraints are effectively included to make the application more protected. Along with that user authentication and validation process provides an adept access control to the framework.

E. Memory Optimization Algorithm

The proposed memory optimization algorithm is divided into two phases. The first phase includes in finding efficient VM with large free memory, whereas the second phase involves in job deployment. Allocation of all jobs to less loaded server results in Server optimization and less consumption of virtual machines, and also provides cost effectiveness. The Server Load is calculated by measuring the physical memory usage and measuring the CPU processing time. After the measurement, the jobs are deployed to the optimal VM. Here, the E-learning process is deployed to the less loaded server and all the E-Learning Contents are loaded to that machine. Hence, it results in faster execution of given process with less cost and energy consumption. The memory optimization algorithm, framed in this paper is presented below.

The following algorithm demonstrates the decisive function of the proposed work. When a process is finished by a VM, the information will also be updated on to the allocation table in data center controller to assist the further job assignment process. Thus, the approach tremendously outperforms the limitations of traditional web-based learning methods.
EXPERIMENTAL RESULTS AND ANALYSIS

In the e-learning approach under a dedicated cloud environment, the evaluations strongly rely on the load forecasting and QoS metrics of multiple VM. The efficiency of job allocation is considerably increased through the proposed work. In order to provide evidence for the efficiency of the proposed e-learning system, the experimentation has been made with the creation of real-time cloud environment by processing multiple virtual machines. Virtual machines created by instantiating two Operating systems by the cloud tool called “VMware”.

For the sake of explanation, performance analysis is made between two selective virtual machines among all in the cloud environment, which are termed as VM1 and VM2. Server load is calculated by measuring the physical memory usage and CPU utilization according to the equations given in section 3.1. The QoS metrics are also been computed in terms of bandwidth consumption and resource utilization of those machines. These computations tend the process to select an optimal VM to allocate the learner’s demand.

A. Measurement of Physical memory usage:

Generally, the physical memory calculation is done in bytes. When the job is assigned to a server with large free memory, the processing time is considerably reduced and the end user acquires results with reduced response time. Figure 5 exemplifies the pictorial representation of physical memory usage of the virtual machines VM1 and VM2 in terms of bytes. It is apparent from the figure that VM1 uses less memory than the VM2. Hence, it is decided that the request will get fast response when it is processed with the VM1.

B. Evaluation of Cost effective servers:

In order to measure the cost effectiveness of a server, the changes in a small number of easily tracked system parameters such as network bandwidth and the size of data exchanged over the networks are to be monitored. Apparently, with the determinations stated earlier, the servers with less cost is evaluated by means of measuring bandwidth, which leads to the energy efficient server paradigms.

Figure 6 represents the cost evaluation of VM1 and VM2. It is shown from the figure that VM1 produces services with lest cost when compared to VM2. Hence, from these evaluations, it is found that the machine VM1 has less memory and bandwidth consumption.
C. Analysis of Server’s QoS:

The quality of service of two virtual machines is analyzed to substantiate that the server VM\textsubscript{1} is the effective VM among all in the cloud environment. The analysis has been processed with determination of CPU utilization, memory usage and bandwidth consumption as explained in section 3.2. Figure 7 depicts the performance evaluation of two virtual machines.

![Figure 5: Physical Memory Usage of VM\textsubscript{1} and VM\textsubscript{2}](image)

![Figure 6: Cost Evaluation of VM\textsubscript{1} and VM\textsubscript{2}](image)

![Figure 7: Performance Evaluation of VM\textsubscript{1} and VM\textsubscript{2}](image)
According to the calculations, the figure results that VM$_1$ comparatively provides high QoS than VM$_2$. That is, less loaded server leads to less execution time for serving the assigned E-learning process or jobs, whereas less Execution time results in high QoS value. In this case, it is conclusive that VM$_1$ is the optimal server for specific e-learning process allocation. Moreover, the information is updated on to the data center controller for assisting further job allocations.

In a dedicated cloud environment, the response time in serving a particular request increases, when the number of users increases. Figure 8 represents the above statement. Nevertheless, the response time for providing a service is considerably reduced by the affirmed memory optimization algorithm, which paves way for selecting optimal VM for processing the request.

Content management is such an important task, which is performed by this e-learning system by assessing the learner’s knowledge and tracking their activities. For this experimentation, consider the E-learning site is based on delivering knowledge about JSP contents to the novices. The content of the e-learning site is updated as per the results of the novice’s performance in the assessment test provided by the site administrator.

Figure 9 shows the learner’s performance in percentage, obtained by the assessment test. In addition to the learner’s knowledge assessment, session tracking mechanisms are incorporated for obtaining the most visited and least visited sites. Figure 10 exemplifies the site visits for particular e-learning process, specifically, here on learning JSP. With those results, based on learner’s performance and site visits, the content on the site is managed. That is, the contents of least visited sites are to be improved and making the content availability based on the learners knowledge.

![Figure 8. No. of Users Vs Response Time](image8)

![Figure 9. Learner’s Performance (%)](image9)
Hence, the developed e-learning system works on the consideration of learner’s activities and their expectations to offer satisfied results with better improvements.

V. CONCLUSION AND FUTURE WORK

Cloud computing allows the efficient utilization of technological infrastructures, which is of great interest in e-learning process. In this paper, a novel memory optimization algorithm has been proposed with the exploration of potential cloud benefits such as scalability, fault-tolerance and green computing in educational measures. In addition he proposed e-learning system incorporates load balancing to provide more efficient use of resources and session tracking for cloud environment, and the content is adequately managed with respect to the user activities. Furthermore, examinations have been done in the aspect of enhancing the novice’s performance. The experimental results show that the adduced work decreases the response time and amends the overall performance of e-learning environment in serving the learner’s demands.

The e-learning content could be more effectively managed with the incorporation of web 2.0 platform in future studies. Another leveraging area for future enhancement is developing personalized learning service using genetic algorithm.

REFERENCES


