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An E-learning Ecosystem Based on Cloud Computing Infrastructure

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Abstract

Recently the research community has believed that an e-learning ecosystem is the next generation e-learning. However, the current models of e-learning ecosystems lack the support of underlying infrastructures, which can dynamically allocate the required computation and storage resources for e-learning ecosystems. Cloud computing is a promising infrastructure which provides computation and storage resources as services. Hence, this paper introduces Cloud computing into an e-learning ecosystem as its infrastructure. In this paper, an e-learning ecosystem based on Cloud computing infrastructure is presented. Cloud computing infrastructure and related mechanisms allow for the stability, equilibrium, efficient resource use, and sustainability of an e-learning ecosystem.

1. Introduction

In recent years e-learning has grown into a widely accepted learning model. Innovative changes of e-learning applications have also been witnessed. Recently the research community has believed that an e-learning ecosystem is the next generation e-learning [1] [2].

The current models of e-learning ecosystems [3] [2] lack the support of underlying infrastructures, which dynamically allocate the required computation and storage capacities for an e-learning ecosystem. Infrastructure is one of the important constituents of an e-learning ecosystem and has the direct impact on the flourish and sustainability of an ecosystem.

Cloud computing [4] has been a hot topic of computing paradigm. Enterprises currently employ cloud services to improve the scalability of their services and to deal with bursts in resource demands [5]. Cloud computing is the promising infrastructure which can provide tremendous values to e-learning ecosystems, due to its abilities of delivering computation and storage resources as services.

The main contribution of this paper is to introduce Cloud computing into an e-learning ecosystem as its infrastructure to build a sustainable and flourishing e-learning ecosystem. This allows for some crucial and amusing features: (1) to track the situation of resource configuration and utilization in real time, allocate resources on demand, and make full use of resources; (2) to allow workloads to recover from unavoidable hardware/software faults; (3) to promote the evolvement or extinction of learning species (including learning contents, services, and applications).

This paper is organized as follows. Section 2 describes what Cloud computing can provide to an e-learning ecosystem. Section 3 demonstrates the architecture and mechanisms of an e-learning ecosystem based on Cloud computing infrastructure. Section 4 is the summary.

2. Cloud computing

Cloud computing has become one of the hottest buzzwords in the IT area. Many companies and institutions are rushing to define clouds and provide cloud solutions in various ways. However, there is still no widely accepted definition for Cloud computing.

A cloud is a type of distributed data center which delivers infrastructures as services. It consists of massive resources, and provides some mechanisms to provide, reimage, workload rebalance, de-provide, and monitor those resources. It represents as one or more unified resource entities, and renders users/applications with services to access those resources without knowing the detailed information.

One of the most important feature ideas behind Cloud computing is scalability, and the key technology which makes it possible is virtualization [7].

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Virtualization breaks down the physical barriers inherent in isolated resources, and automates the management of these resources as a single entity through hypervisor technologies such as VMs [8].

Cloud computing allows an e-learning ecosystem with the infrastructure which is reliable, flexible, cost-efficient, self-regulated, and QoS-guaranteed. The contribution of Cloud computing to an e-learning ecosystem mainly contains those aspects as follows:

1. Cloud provides QoS-guaranteed infrastructures, e.g., time, cost, reliability, and hardware performance like CPU bandwidth and memory size, and sustains SLA-oriented resource allocation [5].
2. Cloud provides the support of varies of applications, making it convenient and rapid to get the required computation and storage resources.
3. Cloud provides real-time configuration information and resource utilization information, allocates resources on demand, and improves the usage rate of resources.
4. Through the automatic resource management, emergencies can be solved rapidly, and labor-intensive jobs can be achieved. Therefore, the cost is cut down.

3. An e-learning ecosystem based on Cloud computing infrastructure

3.1. Architecture

An e-learning ecosystem based on Cloud computing infrastructure is composed of three layers: Infrastructure layer, Content layer, and Application layer. It is also with four *ad hoc* modules: monitoring module, policy module, arbitration module, and provision module, as is shown in Figure 1.

Infrastructure layer is the resource pool of an e-learning ecosystem. The infrastructure is managed by Cloud computing platform. Hardware and software virtualization technologies are used to ensure the stability and reliability of the infrastructure. Supplying computation and storage capacities for higher layers, it is the energy source of an e-learning ecosystem.

Content layer mainly consists of e-learning contents, such as Web file systems, database systems, Web Services, and so on. Except for content storage and maintenance, this layer exposes the standard interfaces and APIs of contents for higher layers.

Application layer consists of e-learning services, systems, tools, and so on. It also provides functions and interaction interfaces for users or other programs.

Monitoring module is keeping track of the executions of requests, the real-time configuration information and resource utilization levels of species, including the health of CPU, memory, I/O, and so on. The data of monitoring module is the source to adjust the balance of an e-learning ecosystem.

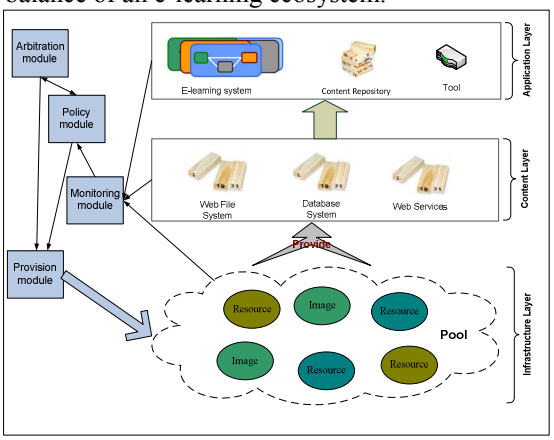

Figure 1. Architecture of an e-learning ecosystem based on Cloud computing infrastructure

Policy module establishes and maintains the teaching and learning strategies, the run-time and resource scheduling strategies. According to the data from monitoring module and the strategies of its own, policy module establishes specific solutions, and then triggers provision module. Policy module also decides which species to get higher priorities on resource scheduling according to some e-learning policies in order to safeguard the running of critical businesses. Policy module is the core of an e-learning ecosystem.

In the ***arbitration module***, some policies are made by experts manually; requests from users are completed; and some disputes among species within the e-learning ecosystem are solved. Arbitration module amends, adjusts, and improves the resource allocation and management. It also establishes usage modes for different kinds of users based on the learning styles, learning preferences, and cognitive levels. Arbitration module is an efficient complement to the policy module, while the privilege of its policy is higher than the one in the policy module.

Provision module starts the execution of resource allocation solutions set by the policy module and arbitration module, and deploys resources referred to users or species automatically in a short time. If the request comes from a user, some related information such as IP, user name and password will be supplied.

3.2. Mechanisms

Here four mechanisms are presented, which are mainly introduced by Cloud computing infrastructure to guarantee the running of an e-learning ecosystem.

Pre-scheduling mechanism

The accesses towards contents and applications in the e-learning domain have some rules, e.g., 80% of

the accesses are focusing on only 20% e-learning contents and applications, bursts in the access demands often happen before the examinations, and so on. Based on these rules, policy module is able to forecast the access loads, and automatically pre-schedules resources for the hot contents and applications before their peaks to safeguard the performance in concurrent access. Making use of the pre-scheduling mechanism, the overall quality of services will be ensured by lesser resources redundancy, and I/O costs will be reduced.

Early warning mechanism

Although benefiting from the pre-scheduling mechanism, health of some species may be unpredictably exacerbated sometime. The specific performances are that the average response time (from the monitoring module) is turning long or otherwise. Once the monitoring data reaches its threshold, policy module will regard it as in crisis. It establishes the corresponding scheduling solution, and then triggers the provision module to assign resources (the standby resources or idle ones currently belonging to some other species) to the target species to ease the crisis. The scheduling process occurs within the e-learning ecosystem, and does not affect the normal use of users. Through the early warning mechanism, an e-learning ecosystem can deal with bursts in resource demands and optimize the allocations of resources.

Self-recovering mechanism

The infrastructure of an e-learning ecosystem consists of a large number of physical machines, and hardware/software faults would be unavoidable. Due to those failures, the quality of services of the e-learning ecosystem would be degraded; some species would even suffer a disaster. The self-recovering mechanism makes it quick enough to recover from unavoidable hardware/software failures. Once machines are found in fault by the monitoring module, species depending on it peremptorily generates the candidate resources for substitution in high priority.

Evolutionary mechanism

An e-learning ecosystem promotes the evolvement or extinction of a species to ensure its metabolism and proper usage of resources through the evolutionary mechanism. The visits of users to a species (from the monitoring module) are a key condition to judge its evolutionary line. If the visits towards some species are lower, resources belonging to it will be decreased. When the configuration and resource consumption of a species approach their bottom thresholds, policy module asks arbitration module for a revocation of support for the species and marking it as extinct. Through the evolutionary mechanism, the overall quality of species and the efficient use of resources are ensured in an e-learning ecosystem.

4. Conclusions

In the traditional e-learning ecosystem, physical machines are usually simply and exclusively stacked, and most resources are deployed and assigned for some specific tasks. Moreover, the utilization of those resources becomes urgent problem.

In this paper, an e-learning ecosystem based on Cloud computing infrastructure is presented. Cloud computing realizes an e-learning ecosystem with the infrastructure which is reliable, flexible, cost-efficient, self-regulated, and QoS-guaranteed. It has some mechanisms to guarantee the teaching and learning activities, the quality and the running of the ecosystem.

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6. References

[1] Loma Uden and Ernesto Damiani, The future of E-learning: E-learning ecosystem, Proceedings of the first IEEE International Conference on Digital Ecosystems and Technologies, Cairns, Australia, 2007, pp. 113-117.

[2] Vanessa Chang and Christian Guetl, E-Learning Ecosystem (ELES)-A Holistic Approach for the Development of more Effective Learning Environment for Small-and-Medium Sized Enterprises, Proceedings of the first IEEE International Conference on Digital Ecosystems and Technologies, Cairns, Australia, 2007, pp. 420-425.

[3] Brodo, J. A. (2002), Today's Ecosystem of e-learning, Vice President, Marketing.

[4] Aaron Weiss (2007), Computing in the Clouds, netWorker, Dec. 2007, 11(4):16-25.

[5] Rajkumar Buyya, Chee Shin Yeo, and Srikumar Venugopal, Market-Oriented Cloud Computing: Vision, Hype, and Reality for Delivering IT Services as Computing Utilities, Proceedings of the 10th IEEE International Conference on High Performance Computing and Communications, Dalian, China, 2008, pp.5-13.

[6] S.T.A. Pickett and M.L. Cadenasso, The Ecosystem as a Multidimensional Concept: Meaning, Model, and Metaphor Ecosystems, Ecosystems Journal, Springer, New York, 2002, 5, pp. 1-10.

[7] M. Tim Jones, Cloud computing with Linux, 10 Sep, 2008. http://www.ibm.com/developerworks/library/I-cloud-computing/.

[8] Greg Boss, Padma Malladi, Dennis Quan, Linda Legregni and Harold Hall, Cloud Computing. http://www.ibm.com/developerworks/websphere/zones/hipods/.