

Cloud Computing Adoption for Software Engineering Learning Environment: Set of Guidelines derived through Primary Research

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ABSTRACT

Software Engineering (SE) is a well-known education discipline which focuses on the study of analysis, design, implementation and maintenance of software. There are various approaches in teaching SE courses at university level, however all approaches stress on blending the theoretical concepts with the practical knowledge. In 21st century, students can no longer be restricted to the traditional teaching methods like the lecturer lecturing and the student listening in a typical classroom environment. Software engineering field requires even more integration of technological aspects keeping in view the demanding job market. Cloud computing is one of the latest trends in IT. Its value has been proven effectively in various sectors including the education sector which motivated the authors to explore the study mechanisms of software engineering programme and look at the possible improvements using cloud-based solutions. In a strive to accomplish this, various data collection techniques were applied to get the questions answered and to achieve the aim of this research which is to utilize cloud for better software engineering learning environment. To achieve this, 325 software engineering students from three big universities (representation from both public and private sector) were chosen to participate in the survey. A total of six software engineering lecturers and three IT heads (decision makers) among the same three universities were interviewed. The results obtained from this exercise showed various problems related to the teaching and learning environment faced by SE students. Software engineering lecturers are also facing more or less the same issues while teaching in the labs. Students and lecturers were pleased to see the various features of the cloud and its usefulness in minimizing the constraints. We noticed that both lecturers and students are ready to adapt cloud computing as an effective solution to existing problems in order to enhance the overall teaching and learning environment. Thus, set of guidelines to implement SE tools on the cloud were derived.

KEYWORDS

Cloud Computing, Software Engineering, Learning Environment, E-Technologies in Education, New Trends in Education

1 INTRODUCTION

Cloud computing has emerged as an adaptable technology in many organizations due to its versatile characteristics like scalability and usage of virtualized resources [1]. Cloud Computing has a significant impact on the educational environment. This research reviews the benefits of cloud in enhancing the educational environment and particularly in encouraging the universities to use lab facilities extensively.

Cloud computing users gain the illusion of resource availability as an infinite on-demand resource, which enables storage and huge amounts of information on the cloud. There are several benefits of incorporating cloud computing in education sector. By utilizing the cloud in education, universities would have cost effective, highly portable and maintenance-free solutions which in turn will improve collaboration and communication. Another benefit is the readiness of students to enter the job market.

In this research, the benefits of adapting cloud computing by educational institutes (especially within Malaysia as only Malaysian universities are considered) have been discussed at length [2]. The possible contribution that cloud computing can deliver is also stated in this article.

2 ISSUES IN SOFTWARE ENGINEERING LEARNING ENVIRONMENT

Learning environment is one of the key segments of any education system. Classrooms, labs and library are typical components of SE learning environment. This research is focused on the use of labs and how the lab specific learning environment can be enhanced using cloud as a solution. The main issue that this research is trying to address is the availability, maintenance, accessibility, scalability, compatibility and resource utilization of software and hardware tools used by the software engineering courses. This research specifies a need for a solution that caters for at least the following:

- mechanism to upgrade the recommended software
- mechanism to upgrade the hardware in order to meet the needs of the software
- cater for the growing numbers of students
- allow more students to use the lab resources simultaneously
- provide access of required software at any needed time
- access to high capability tools to practice, build, develop and deploy programs
- cost effective maintenance of lab

To provide a conducive learning environment for SE students, the lab setup needs considering various factors like number of computers, space to place the computers, network aspects, electricity considerations and most importantly the necessary hardware specifications. All of these issues should be looked at as they will consume a lot of resources e.g., money and man power.

3 WILLINGNESS IN ADAPTING CLOUD-BASED TEACHING AND LEARNING

3.1 Students' Perspective

A survey was conducted among software engineering students in three different universities in Malaysia (APU, UTM and UM) to find out the current issues related to their learning environment as well as their attitude toward adopting cloud

computing as a solution to their problems. A total of 325 students participated in the survey.

The survey results indicate that the current teaching and learning resources utilized for SE students are quite limited in their scope. One of the limitations is the mandatory requirement of attending the lab sessions. Students need to attend the labs at a prescribed time set aside the constraints of number of PCs, licenses and so on. This reflects that the lecturer is bound to follow the availability of lab slots in order to book it for any curriculum requirement. Regarding the question of compulsion of lab usage, the survey showed that the majority of SE students believe that their courses cannot be taught effectively without experiencing the practical part of it which can only be achieved through attending the labs. Most of the students are concerned that they should be allowed and provisioned to use the lab resources at any given time for revision of course material, practice and assignment preparation. Typically majority of the SE courses consist of both theoretical and practical elements, therefore understanding of the theoretical components are naturally dependent on the comprehension of applied segments. Due to the stated issues that relate to the labs' availability, majority of SE students agreed in using the online lab resources, especially as they will be allowed to use the required tools anytime without any constraints. Regarding the question of how conveniently they are able to find suitable software tools for their courses, the survey results indicate that majority of SE students face difficulties of compatibility, availability, portability and licensing of software. However they all seem willing to accept any changes that would help them eliminate part or all of these issues. The survey also showed that the majority of SE students are currently using the traditional processes of teaching and learning. Nonetheless, they are more than willing to accept changes in order to use the latest technologies. The survey also specify that 82% of the students are familiar with the cloud applications like Google Docs etc., therefore the paradigm shift from a traditional lab to a cloud-based state of the art lab is considered well-anticipated by students.

3.2 Lecturers' Perspective

Interviews were conducted with six software engineering lecturers and three IT heads (from the three universities stated before) to figure out whether the current teaching and learning resources should be reconsidered in light of the students' needs. Questions were also asked on whether labs can be conducted effectively online; what necessary tools are recommended for SE students to use; what are the most common issues with these tools in terms of compatibility, availability and portability; and whether they would be willing to accept changes to promote the existing learning environment.

Following is a brief description of the answers provided by the selected SE lecturers during the interview sessions which shows their inclination towards adopting cloud computing based teaching and learning

There is always a need of using innovative, highly effective and technology-specific techniques in educating students therefore ideally teaching methodology needs to be constantly reviewed looking at the demands of that era. Software engineering field requires even more integration of technology keeping in view the demanding job market. These interviews with the SE lecturers specified that they are agreeable with any technological enhancements, especially if it is for the purpose of improving the teaching and learning experience. They all agreed that current labs are not enough for accommodating the increasing number of students as well as for meeting the needs of the students. Considering that the lab requirements for SE courses are relatively high, universities don't have the resources, infrastructure and sometime budgets to meet the quality expectations. Lecturers emphasized the need of software tools for various SE subjects which reflect the importance of the lab-based learning environment.

Availability of labs is a major concern everywhere. Most of the time this issue is addressed by dividing the larger classes into smaller and manageable groups, however it all adds to the restrictions of individual students' lab consultation

times. Issues related to booking of labs are a common concern for most of the interviewees. Moreover ensuring the suitable environment in terms of managing place, machines, technical staff, air-conditioning etc. are few major obstacles that almost every university is facing. Hence, the SE lecturers are always in anticipation of any optimal solution that significantly reduces these limitations. These interviews indicate that the SE lecturers are eager to use the online lab facility. As they always need various specifications of tools to be installed, all interviewees were keen to use the cloud-based solution to resolve their problems.

4 GUIDELINES TO IMPLEMENT SE TOOLS ON THE CLOUD

The following are the guidelines to implement SE tools in the Cloud. The implementation of these guidelines was tested using a public cloud (Amazon).

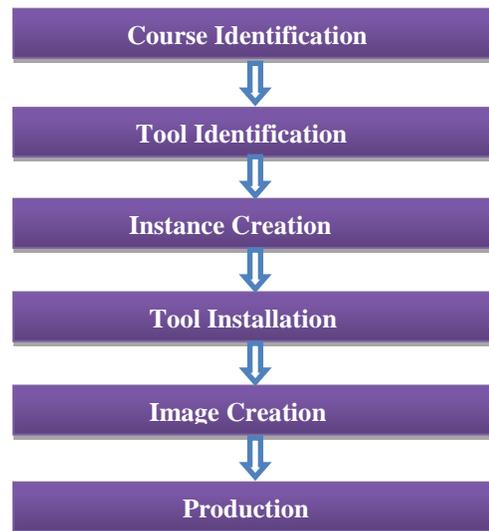


Figure 1. Guidelines to Implement SE Tools on the Cloud

4.1 Course Identification

This step involves identifying the SE courses that require usage of software tools. Since majority of SE courses are a combination of theoretical and practical approaches, all such courses will be shortlisted that are recommended to be taught in the lab. The courses should be listed and filtered in

accordance with the programme (e.g. SE in this case) requirements.

4.2 Tool Identification

This step involves identifying the appropriate tools for the courses. Since the practical-natured courses are already listed, the required tools for these courses need to be identified in this step. There could be multiple tools serving the same purpose, but the appropriate tools would be selected based on precise curriculum requirements.

4.3 Instance Creation

This step involves creating an instance with the appropriate specification that would conform to the identified tools and courses. Amazon Elastic Computer Cloud (Amazon EC2) was chosen to test run the instance creation. It enables the user to launch and manage different types of operating system instances (such as Windows Server instances and Linux/UNIX instances) in Amazon data centers. The instances can quickly be launched using the AWS Management Console [3].

4.4 Tool Installation

This step involves installing the appropriate tools that were identified in the Tool Identification step. Since the tools have already been identified, installing them on the created instance is straight forward.

4.5 Image Creation

This step involves creating an image of the installed tools in the created instance. When all identified tools are installed and resided in the instance, an image of the instance is created. This image would be taken as the reference for creation of more instances [3].

4.6 Production

This step involves providing the instances with the necessary tools for the students. This step follows from the Image Creation. The created image will suffice for SE students because they all share and use the same tools. For example, when new students enroll into the University, they would have the same instance until they graduate. Enabling the students to use the given instance

with specified tools is done through implementing a Web Portal which would enable them to access their specified instance at any given time and at any given place.

5 BENEFITS OF USING A CLOUD BASED LABORATORY (CBL) FOR SE STUDENTS

There are notable differences between a traditional and a cloud-based laboratory (CBL). Table (1) illustrates some of the key differences between these two setups.

Criteria	Traditional Lab	Cloud Based Lab (CBL)
Cost	High	Low
Infrastructure	Yes	No
Maintenance	Yes	No
Accessibility	Yes	Yes
Scalability	Limited	Unlimited
Compatibility	Yes	Yes
Resource Utilization	Varied utilization	High utilization

Table 1. Comparison between a traditional and a cloud-based laboratory (CBL)

Several factors were considered for the comparison criteria that include cost, infrastructure needs and maintenance requirements. We also catered for factors like accessibility, scalability, compatibility, affordability and resource utilization. The cost factor was derived by comparing the total expenditure that is required to setup the necessary components of both traditional lab and CBL. It includes the costs of machines, hardware, and software. The infrastructure was taken into account by considering the structural components and facilities of both traditional lab and CBL. It includes components like servers, physical storage etc. The maintenance aspect was considered by looking at the configuration needs and updating requirements of the installed hardware and software for both traditional lab and CBL.

Time and location based constraints in both traditional lab and CBL setup were used to reflect the accessibility factor. Scalability was measured in terms of the number of enrolled students and the growing needs. Compatibility was taken into account by finding out the alteration needs and requirements of any special hardware to work with these labs. Finally the resource utilization was considered by looking at the consumption of the available resources like storage, network, and computer resources.

Currently many of the educational institutions are facing problems in providing the needed IT infrastructure especially for research activities due to the financial crisis [4]. This problem can be minimized or at least can be significantly reduced by getting benefitted from cloud technology rather than by building a complex infrastructure with maintenance and configuration issues associated with it [5]. Hence the proposed solution is important to be adapted quickly in the education sector.

The learning content can be easily created and deployed in cloud-based environments [6]. Moreover, CBL is advantageous because of its ability to host the tools needed for system users. By building a cloud-based education system, we can ensure optimal utilization of computer technology and improvement in the quality of the overall teaching and learning process [7].

There are plenty of benefits for academic staff, students and university management in following this approach. It will enhance the level of interactivity among the students and staff. In fact the use of cloud will help to make the teaching and learning environment scalable which will help in cost cutting [8]. Students will no longer be required to install the specific applications or buy an access code for training toolkits (such as myITlab). Administrators will save a lot of their time because updating, licensing, and configuration issues will be eliminated using the cloud. All of these elements would add to the cost reduction and ease of access and usage [9].

5.1 Benefits for Students

The most visible benefit for SE students to use cloud-based infrastructure is the availability of the needed resources at any time and at any place [10]. The portable nature of the cloud will enable students to work from multiple computers and operating systems [11]. Students will be able to access the system tools and other software regardless of time or location restrictions. As mentioned, currently students are facing availability and portability issues; however the proposed system guarantees the solution of these problems. It also promises to eliminate problems like networking issues, hardware or software restrictions, lack of resources, maintenance requirements etc. which ultimately would enable students and academicians to focus on their tasks without any distractions. Better resource utilization will promote ease of use and availability of required services which would help students to accomplish their tasks faster [12].

We expect that an improvement in overall teaching and learning experience would lead to produce better quality students having more in-depth understanding of the concepts and applied skills which are essential for SE graduates. It would enable the students to address the needs of a leading technology. Therefore, it eventually will help to improve the overall student performance and will provide them experience in dealing with such technology. In turn, it is also assistive for their job prospects because the technology shift towards cloud has already been started in industry and students comfortable in using this technology will certainly have an edge in the job market [13]. Programming is an important component of any software Engineering degree. Institutes need to have the latest programming tools and IDEs to support a better programming experience for their students. By utilizing the cloud, programing language constraints can be diminished as we no longer need the time consuming downloads, complex setup configurations, use of additional resources, etc. [13]. Therefore students will only be concerned to write and execute the code in the specified programing environment.

5.2 Benefits for Faculty

Cloud technology would provide the access portability, resource availability, flexibility and agility to the hosted applications [14], thus the lecturer would find it easier to construct multiple difficulty levels for beginner and advanced audience.

Faculty will not be bothered by the maintenance issues anymore which eventually will impact positively for the overall learning environment [13]. The faculty would expose the students to real situations that cannot be faced in locally simulated environments, thus building a deep knowledge base for the students [13]. Hence the teaching process will improve and it would be more efficient without placing additional loads on the faculty [15].

5.3 Benefits for Universities

In utilizing cloud-based education, institutions are expected to be the top beneficiaries, as they would have the opportunity to optimize their resources more manageably which will in turn benefit the number of enrollments. Student numbers will also benefit from increased resource availability, high accessibility, better job opportunities and improved quality of students [15].

A key advantage that the university management (network administration department) would get by utilizing the cloud is that they don't have to worry about software licensing issues [16] which also will help in eliminating the cost associated with it [17]. Another finding indicates that some specific hardware constraints would disappear mainly due to virtualization feature which gives the students the ability to share the resources with multiple operating systems and virtual hardware platforms [14]. Thus, the administrators would have the choice to run large-scale applications without having to consider the resource limitations since with the use of cloud, universities will have the provision of all the required resources and practically unlimited space.

Maintenance would be minimized because the cloud would take care of the maintenance issues. The main concern that the administration has to

take into account is that the service availability of cloud service provider (CSP) has to be addressed and ensured on the service-level agreement (SLA). The service availability should be a matter of concern, especially as it involves identifying the backup and disaster recovery in case of down service of CSP [18].

6 CONCLUSION

The proposed solution suggests utilizing the power of cloud computing in enhancing the learning environment of SE students. The difficulties faced by SE students related to the availability of lab facilities, tools and the other mentioned issues can be solved by implementing the power of cloud computing. Thus, as per the proposed solution, it is highly recommended to use cloud computing to help improve the SE learning environment.

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