Teaching ICT Infrastructure Supported By Cloud Service Azure

Full Paper

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Abstract

In this paper the use of Microsoft Azure in the teaching of ICT infrastructure components is described. In addition, the article includes the analysis of the effect caused by Microsoft Azure on different learning goals.

In addition, the understanding of the learning paradigms is needed and we claim that constructivism works in the most successful way while setting up new services such as ICT infrastructure elements on the cloud.

This article presents how we organized an optional coursework on Microsoft Azure for the students. The coursework included three parts: setting up virtual machines, setting up virtual storage, and setting up virtual networks. It also includes the analysis of the coursework based on the pre- and post-questionnaires. The empirical results did not show significant difference between those who completed the coursework and who did not complete the coursework. However, in the open-open ended responses, the students showed the positive attitude to the coursework and this reflects the quality of learning and support for the constructivist-learning paradigm. However, these responses show the need to add service management into this coursework.

Keywords

ICT infrastructure, cloud services, IaaS, teaching information systems, constructivistic learning paradigm.

Introduction

The meaning of ICT infrastructure has been clearly shown in the curriculum recommendations of ACM and AIS (Topi et al. 2010). Degree programs for information systems (IS) should include a course on ICT infrastructure.

The learning in IS should be supported by real life experiences which connect the theory to the practice. According to the constructivist learning theory (constructivism), a learner constructs new knowledge based on what he/she already knows (Brandt, 1997). In learning based on constructivism the following elements should be included in learning activities (Jonassen, 1994): representations of the reality in many ways, presenting the complexity of the reality, knowledge construction, authentic exercise, reflection in learning tasks, and interaction with experts and peer learners.

One way to organize learning activities on ICT infrastructure according to constructivism is using infrastructure as a service (IaaS) on the Internet. The need for this is also practical. Gartner (2016) reports that "IaaS market has been growing more than 40 percent in revenue per year since 2011, and it is projected to continue to grow more than 25 percent per year through 2019". In ICT infrastructure teaching this means that more content and class hours are needed for IaaS. This is an opportunity for instructors, because by delivering IaaS classes and assignments ICT infrastructure can be taught in a realistic way in the spirit of constructivism.

In the next sections we present the background of this study including ICT infrastructure and cloud services. This is followed by research questions and methodology, results of the study and the discussion.

ICT infrastructure and its components

According to Laan (2013), ICT infrastructure of an enterprise or a public entity consists of following elements:

- data centers,
- servers,
- networking,
- storage,
- virtualization,
- operating systems, and
- end user devices.

In addition to the basic components of ICT infrastructure, Laan (2013) has suggested the evaluation of these components from three perspectives. These are

- availability,
- performance, and
- security.

The availability attribute reflects that the components of ICT infrastructure are available as much as possible. The performance attribute includes that the components of ICT infrastructure perform well enough for satisfying users' service needs. The security attribute reflects that the components of ICT infrastructure maintain the integrity, confidentiality, and resistance of attacks in ICT services.

According to Laan (2013), IaaS is the trend of infrastructure in which the elements of ICT infrastructure are transferred to the cloud. This is connected to the virtualization of the services and data centers. In data centers it is possible to run servers and storages in the scalable way with any operating system supported by a data center company such as Microsoft, Google or Amazon.

Cloud Services and IaaS

Cloud services can be seen as services in which computing capacity has been outsourced to the external servers and these servers can be accessed through Internet. These services can be classified in different classes (Hassan, 2011). One common classification includes four types of cloud services (Wag et al., 2010). These are Software as a Service (SaaS), Platform as a Service (PaaS), Data as a Service (DaaS), and Infrastructure as a Service (IaaS). SaaS includes application software available from the cloud. PaaS is a wider concept. It can be a platform for software development or a platform for administration technology resources. DaaS enables storing data on the cloud for a client organization. IaaS means outsourcing the elements of conventional ICT infrastructure to the resources on the cloud. In Microsoft Azure three elements of ICT infrastructures can be implemented on the cloud (Microsoft, 2016). These are

- virtual machines (or servers),

- virtual storage, and

- virtual networks.

The same elements are also included in related IaaS architectures. For example, Openstack project has introduced the elements IaaS software including the same elements (Openstack, 2016). Openstack recommendations can be considered as the unofficial standard for IaaS, because major companies have joined this co-operation. These companies include AT & T, Ubuntu, Hewlett Packard, IBM, Intel, Rackspace, Redhat, and SUSE as the platinum members of Openstack collaboration. In addition, many other companies are the supporters of Openstack as gold members or corporate supporters.

Methods

Experiment

We built our experiment from Laan's approach (2013), the curriculum recommendation of the ACM and the AIS (Topi et al. 2010), and the mainstream of IaaS explained previously in this paper. And thus, at the University of Jyväskylä in Europe, the themes of the course ICT infrastructure are (1) end-user devices, (2) operating systems, (3) virtualization, (4) storage, (5) networking, (6) servers, (7) datacenters, (8) availability of ICT infrastructure, (9) performance of ICT infrastructure, and (10) security of ICT infrastructure. The course of 2016 lasted seven weeks including lectures (30 hours), two mandatory exercises on datacenters and servers, an optional Azure coursework as well as the final exam. Before our coursework, it was essential to teach the basic concepts of ICT infrastructure area to the students that they had right orientation for the coursework. In addition, the concepts of cloud services and IaaS were introduced in the first mandatory exercise. Datacenters and servers were included in the second mandatory exercise. The Azure coursework was organized during the last three weeks of the course. At the same time we had visiting lecturers from the ICT industry including both public and private sector, but these lectures were not connected to our Azure coursework.

For this study and teaching the benefit of IaaS we organized the Azure-based coursework in which students were expected to set up three different elements of ICT infrastructure on the cloud. These were setting up

- a Linux or Windows Server virtual machine,
- a virtual storage, and
- a virtual network including at least two machines and security (Network Security Group) for these.

The students created these services by using New on Microsoft Azure main menu. Figure 1 demonstrates this. In this example a student starts creating an Ubuntu Server virtual machine.

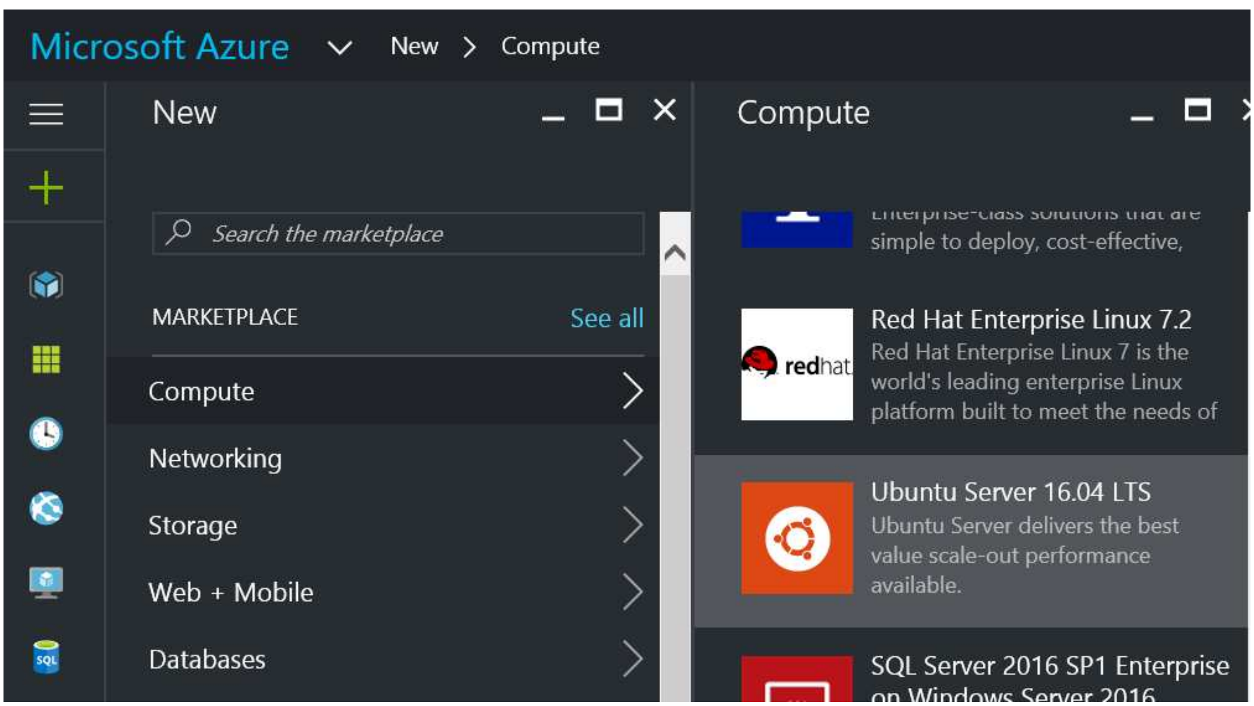

Figure 1. Creating new services on Microsoft Azure cloud.

For these tasks the instructor of the course had created instruction videos and with the help of these videos the students completed the tasks.

To use Azure for setting up IaaS services the students acquired the capacity of 90 euros (100 USD) per month from Microsoft's academic program. In this way it was possible to set up the above-mentioned IaaS services at portal.azure.com However, with this capacity for all options to create services were not possible. For example, the students needed to select the right virtual machine that fitted to their monthly budget limit. The coursework was expected to be conducted as an individual task or in groups of two to five students.

Before the tasks a student/student groups created Azure resources groups for all services they create later. Resource groups were needed to place services logically to groups. In the first task, the students created a virtual machine and tested how it works. The students were expected to create some folders on those virtual machines. In the second task, the students created a basic virtual storage for any kind of content. They were also required to save content on this storage.

The third task was setting up a virtual network and it included three steps. Figure 2 illustrates the basic structure in this task. First step was setting up two subnets for a virtual network. In the second step one or two virtual machines were created to both subnets. The third step included the creation of network security groups (NSGs) for data security and controlling traffic. The other elements shown in the figure 2 were optional because in the creation of these working on shell level and its commands were needed. The course was for the first year students mostly and we evaluated that the first year students are not mature for this yet. At the end, students invited the instructor of the course to review their outcomes.

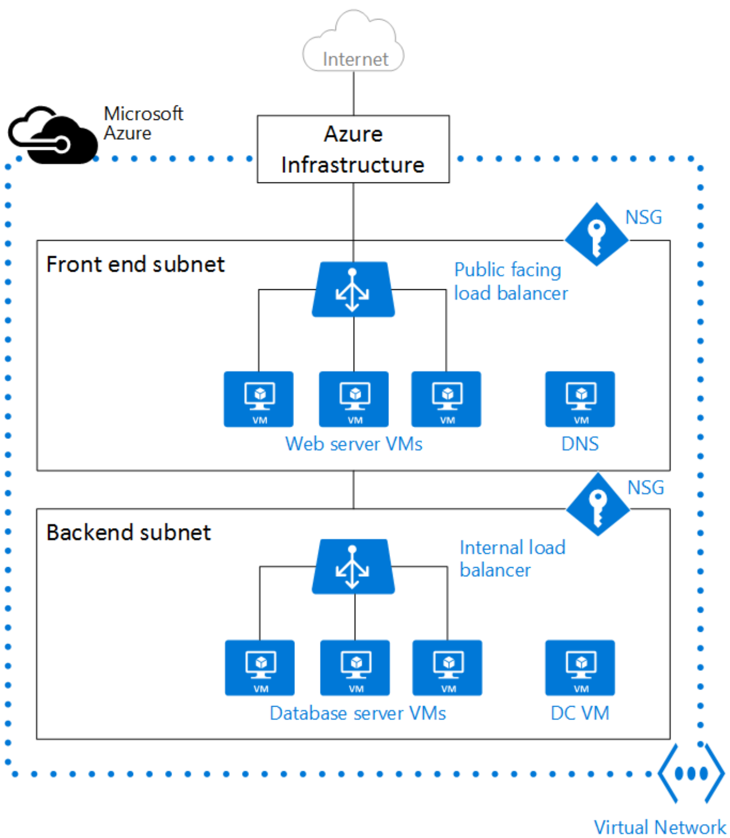

Figure 1. Creating new services on Microsoft Azure cloud (Microsoft, 2017).

The research question of this study was that whether those students who participated in the optional Azure exercise acquired better learning results in the learning of different themes of ICT infrastructure. To answer this question, we used the quantitative analysis and ran a pre- and post-questionnaires. In addition, we collected data on the benefit of the Azure coursework. For the students who completed the IaaS coursework we had an open-ended question in which they clarified positive and negative aspects in the coursework.

To promote the students' participation in the optional coursework, the students acquired credits for the final exam by completing the coursework. Although the coursework was a constructivist part of the course, the teacher's office hours were available as an additional resource to promote their work. The students had three and a half weeks for the coursework before the final examination.

Sample

For this study, we organized a pre-questionnaire at the beginning of the course as well as a post-questionnaire at the end of the course for an experimental group and a control group.

The questionnaires contained 10 major items from the content of the course in which the students needed rate their knowledge according to the Likert scale.

Twenty-three students, 8 females and 15 males, whose mean age was 23 years (range 20-33 years), participated in the experimental group including the Azure-based coursework on the web. They all studied informatics as a major. Three of them completed the coursework individually, and 20 of them in groups of two to five students. We call this group the cloud group in this paper. The participation rate in the lectures was 56% in this group.

Twenty-seven students, 11 females and 16 males, whose mean age was 25 years (range 19-51 years), participated in the control group without the Azure-based coursework on the web. They all studied informatics as a major. The participation rate in the lectures was 67% in this group.

Results

First, we compared the learning of the different elements of ICT infrastructure content between the cloud group and the control group. Means at the beginning are shown below (see table 1). In addition, p values were calculated using the Mann-Whitney test. In the next table (table 2 on next page) the means at the end of the course are shown as well as p values using the Mann-Whitney test. We selected this test because of small sample size.

Theme	Datacenters	Servers	Networking	Storage	Virtualization	Operating systems	End user devices
Cloud group	2.65	2.91	2.00	2.73	2.17	2.26	1.95
Control group	2.41	2.56	1.63	2.44	1.78	1.78	1.59
p value	.320	.159	.117	.188	.106	.032	.081

Table 1. The means and p values at the beginning.

From this data, it can be concluded that knowledge on operating systems in the cloud group was statistically significantly higher than in the control group (p = .032). Concerning other themes, significant differences were not found from our data.

Theme	Datacenters	Servers	Networking	Storage	Virtualization	Operating systems	End user devices
Cloud group	3.17	3.17	3.56	3.30	2.87	3.43	3.96
Control group	3.33	3.19	3.33	3.25	3.00	3.26	3.59
p value	.566	.949	.383	.851	.549	.325	.088

Table 2. The means and p values at the end.

Concerning all themes, significant differences were not found from our data at the end of the course.

Furthermore, we compared the knowledge of non-functional attributes between the cloud group and the control group both at the beginning and the end (see table 3 and 4).

Attribute	Availability	Performance	Security
Cloud group	1.70	1.65	1.74
Control group	1.52	1.52	1.74
p value	.437	.489	.815

Table 3. The means and p values of non-functional attributes at the beginning.

Attribute	Availability	Performance	Security
Cloud group	3.17	3.00	3.26
Control group	3.59	3.18	3.30
p value	.121	.418	.804

Table 4. The means and p values of non-functional attributes at the end.

Concerning all non-functional attributes, significant differences were not found from our data both at the beginning and at the end.

We also collected open-ended feedback on the Azure exercise. The intention of this feedback was the help for the development of the course. In the cloud group 14 students from 23 participants provided open-ended feedback.

The feedback included the connection to the practice as a positive point of view. The participants of the Azure coursework experienced that they have acquired practical skills while setting up the IaaS services.

“In general Azure provided a good start to virtual world. A practical example and a possibility to implement something by myself. It supported theory-based teaching well “

“Azure exercises were interesting. It was nice to realize things at the practical level”

“My opinion is that Azure exercise was good, because it was wide enough to learn the basics of Azure. In addition, the exercise was good for the future”

”I think that Azure exercise was really interesting. It was nice to test things in practice”

”Azure exercise was interesting and it gave new light to the issue, when you were able to test this service by yourself”

”It was relatively easy exercise. I was learning new things”

“From my perspective is was really good, because it made the topics of the course concrete. The exercise was relatively easy, but despite of this easiness it was interesting enough”

“It was great to have practical exercises. Instructions were good and Azure worked”

”I experienced tasks in Azure exercise relative beneficial. Video instructions helped much. We could have had more exercises if possible according to the license. The work was easy to start, because only few settings were needed to get started”

On the other hand, the exercise was criticized because it did not include self-created artifacts.

“At the end Azure exercise was little bit light, because the created set of services was narrow. I experience that I cannot utilize Azure skill in my job application.”

“Azure exercise was mainly trivial typing of computer. It did not include own thinking.”

“It was an interesting introduction to the use of software, but on the surface level only”

“Positive points were doing and learning; learning virtualization, getting familiar with Azure, good instruction and background information. Negative point was that it was too simple exercise. It would require something else.”

“It was an easy-to-do task. The exercise should be upgraded to the next level that the course participants can get more from this task. It was rewarding when thinking about the final grade from the course”

Discussion

The quantitative results of our study reflect that attending the lectures is more significant than building ICT infrastructure on the cloud. There were no significant differences between the cloud group and the control group in the areas to learn except operating systems in which the control group performed better in learning. The notable fact was that the students in the control group participated in lectures more actively. On the other hand, in the cloud group the qualitative data reflects positive attitude and motivation to the Azure-based exercise. It also supports the constructivist view of learning because all coursework participants liked the setting up IaaS services.

In the next step of our research we are going to open these facts. These include studying the coursework from motivational perspective and the improvements of our assignment.

For studying the motivation point of view, we have collected data on the motivation both at the beginning and at the end. In our analysis, we are going to deal with both internal and external motivation. Most commonly in learning from text especially, motivation and learning style are understood both internally and externally (Biggs, 1984; Biggs 1985; Entwistle & Ramsden, 1983; Linnakylä 1988). Internal motivation (or intrinsic motivation) reflects the own personal interest of the student/learner in regard to espousing new knowledge. It is associated with a human's high-level needs such as self-actualization. External motivation (or extrinsic motivation) reflects the need to reach goals set by others.

Secondly, we are going to develop our assignment based on the survey of this study. We can read from open-ended feedback that teaching ICT infrastructure is not only setting up the services. Based on the open-ended responses from the students the lifecycle of ICT infrastructure should be included in our assignment. Thus, service management should be included in this assignment. The use of ITIL (information technology library) can provide the basis for this as the leading standard of ICT management. According to ITIL, the organizations operate in dynamic environments and thus, service management should be included to acquire the best service for business operations (Cannon & Wheeldon, 2007). We can also develop our assignment discussing the concept of dynamic environments more. The business environment of ICT operations and technology change all along. Thus, the service management part of exercise can be based on scenarios. In these exercise tasks based on different possible scenarios the students need to modify the services that they would be compatible with changing needs.

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