

CLLOUD COMPUTING BASED INFRASTRUCTURE IN EDUCATION: INVESTING INTO THE PRIVATE INFRASTRUCTURE OR USING OUTSOURCING SERVICES

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***Abstract.** The main challenge for higher education in the nearest future is the global competitiveness, as the present global market requires the higher schools to present their courses in the international level. Thus, traditional universities must adapt educational infrastructures in response with the global requirement. Outsourcing of cloud computing based services increased over the years. The solutions allow not only create more effective teaching methods and new communication chances for the whole education society, but also to reduce costs of installing and maintaining programs.*

Aim of the article is to prepare a cost/benefit case analysis between investing into the private information and communication technology infrastructure and using outsourcing services. This paper focuses attention on cloud computing based information and communication technology infrastructures of two higher education institutions.

Research methods include analysis of scientific literature, review of legal institutional documentation and reports and interviews with institutional representatives about education practices.

***Keywords:** cloud computing, deployment expenditure, education, outsourcing.*

Introduction

Nowadays in the world of globalization and technological development, the competition between academic institutions is inevitably increasing. With the aim of attracting, more learning organizations are forced to modernize their

information and communication technology (ICT) and seek for innovative teaching solutions. Modern studies are based upon various mobile smart devices in their learning process. It is essential to have an unlimited access to the study materials. Online resources must be accessed from different types of such devices: personal computer, laptop, tablet, or smartphone, at any time and place through the Internet connection.

Many IT leaders like Microsoft, Google, Amazon and IBM provide initiative to support education institutions with the necessary learning services. Some of these tools are free with no cost (Alharthi, et al., 2015). Such information technologies leaders are offering many useful online-based software tools to their clients (Gonzalez-Martínez et al., 2015).

For example, Google corp. includes cloud email, word processing and collaboration tools such as Gmail, Chat and Calendar. Google is providing an online service called Google Docs for several years so far. This is a free office suite, which provides tools to edit text documents, slide presentations, numerical data sheets and presentation files. The work with the office programs is made possible with a help of a web browser. All information is stored in the Google account and can be accessed at any time from any device, which has an Internet connection.

The other market leader Microsoft corp. in 2011 has presented a new service called Office 365. This is an online alternative of MS Office tools, which provides a possibility of communicating and working independently of physical location and types of smart devices. All programs, e-mails, shared documents, calendar events and personal contacts are made available on the personal computers or smart phones via the Internet browser as well (Bukelis, 2012; Miseviciene et al., 2013).

Other learning service Virtual desktop infrastructure (VDI) presents computers desktop in virtualisation mode. The revolutionary model is used to deliver remote desktop working on a remote server of cloud data centre. The model separates software from the basic hardware and provides a focus on what is delivered; it not concerns about how it was delivered or from where it was transferred. With the help of a virtualization, user's working environment (i.e. OS, applications and data) is partly isolated from the hardware making the process of workplace administration easier, ensuring user's mobility needs, and reducing operating loads. The tools allow the end users to access their "virtual desktop" from anywhere, anytime and any devices (Ibrahim, 2016). The users can access their desktop applications by using various devices.

The VDI paradigm implements new sharing capabilities with help so called "thin client" or "zero clients" devices. The devices have no CPU, memory or moving parts. The devices use only 1 to 5 watts electricity. It is less than 10 %

that of personal computer (PC). As opposed to traditional PC, the “zero client” devices can last for 8 to 10 years (Agrawal, 2014).

According to Gartner Magic Quadrant report “on x86 server virtualization infrastructure for 2015 (Gartner, 2015). VMware and Microsoft retained their spots in the top right quadrant, which Gartner reserves for the leaders. Vendors that made it into the niche players’ quadrant are Citrix, Huawei, Odini, Oracle, and Red Hat”.

Above-mentioned ICT services are tied up with different cloud computing technologies. National standards and technology institute (Mell and Grance, 2011) official announces that “the cloud computing is a model, which allows to have a convenient access to the common computer resources, e.g. a computer network, servers, data storages, application programs, and other program tools, with a minimum interference by the service providers”. In other words, the main concept is to eliminate some of the in-house infrastructure parts of ICT systems and instead rely more extensively on outsourced services in accordance with specific needs of an institution (Gonzalez-Martínez et al., 2015). Cloud computing separates service users from dealing with the actual software acquisition and installation difficulties.

The cloud computing services help to improve the education quality by offering accessibility and mobility via the Internet. Such tools enable dynamic and interactive learning and allow the students in different ways to collaborate and communicate more virtually (Alharthi, et al., 2015). The cloud computing solutions allow not only to create more effective teaching methods and new communication chances, but also to reduce costs.

Most of the latest scientific researches wrote about VDI technical solutions or energy saving consumptions. The authors’ research (Di Salvo et.al, 2017) is based on electricity consumption reduction and disregard several other important “green” label-related aspects. The authors (Chang et al., 2016) study investigating intentions from traditional enterprise information systems to private cloud for large enterprises. The author (Lam, 2017) analyses investment efficiency in industries with correlated demand. The research (Wang et. al, 2016) identifies the opportunities and dilemmas IT project when encountering in managing cloud projects, and to develop a system dynamics model to capture the complexity of cloud adoption. The authors in (Byrne et.al, 2016) present the links between ICT prices, technology and productivity. The authors in the article (Mastelic, et al. 2015) perform analysis of cloud computing model with respects to energy efficiency. The authors in (Agrawal, et al. 2014a) analyse how VDI helps not only to reduce cost of infrastructure, but also presents green computing benefits by reducing energy costs. The authors (Ibrahim, et al. 2016) review usefulness and energy reducing problems of VDI and illustrates by some experiments.

As was shown in the latest scientific researches, the scientific publications mostly pay attention on respects to energy saving only. So far, too little attention has been paid to the aspect of costs of the cloud computing based technologies. Our study contributes to filling this gap.

Aim of the article is to prepare a cost/benefit case analysis between investing into the private ICT infrastructure and using outsourcing services.

This article focuses the analysis on cloud computing based infrastructures in two selected academic institutions, namely Kaunas University of Technology and Marijampole College. The cost/benefit case calculation method is based on the source (Baltmeta, 2010).

Participants of study process

Embracing the cloud based technology, it is important to know how much and what users will work with them. The main group of participants of the study process are students, lecturers and administrators. Every higher school may have other additional users that are actually reasonable and useful.

Kaunas University of Technology (KUT) has 10,895 students, of which 7,895 are Bachelor's, 2,648 are Master's, 566 are foreign, and 352 are Doctoral students. The main users of Kaunas University of Technology are students and academic staff as it is shown at the left in Figure 1 (KTU, 2016).

The total number of students at the KUT every year a slight decline. This was influenced by Lithuania's demographic situation and the decline in the total number of graduates in the country. A growing number of foreign students in the recent years reflects work to strengthen the University's internationalization. In 2016 year at University studied 861 foreign students. This represents 8.42% of the total number of university students. The indicator rose slightly compared with 2015.

Marijampole College (MC) - is an educational institution open to advanced technologies and higher education achievements. There are about a thousand students currently studying at the college. The number of students is declining every year. Figure 1 at the right presents the changing trend (MARKO, 2016). The decrease of number of students is caused because some of the students are crossed out of the study program before finishing it for all sorts of reasons, such as, low grades, financial liabilities not met, their own choosing and others. More students takes part-time studies. This can be explained by the facts that older applicants prefer part-time studies. That allows them to work not only in Lithuania but also abroad.

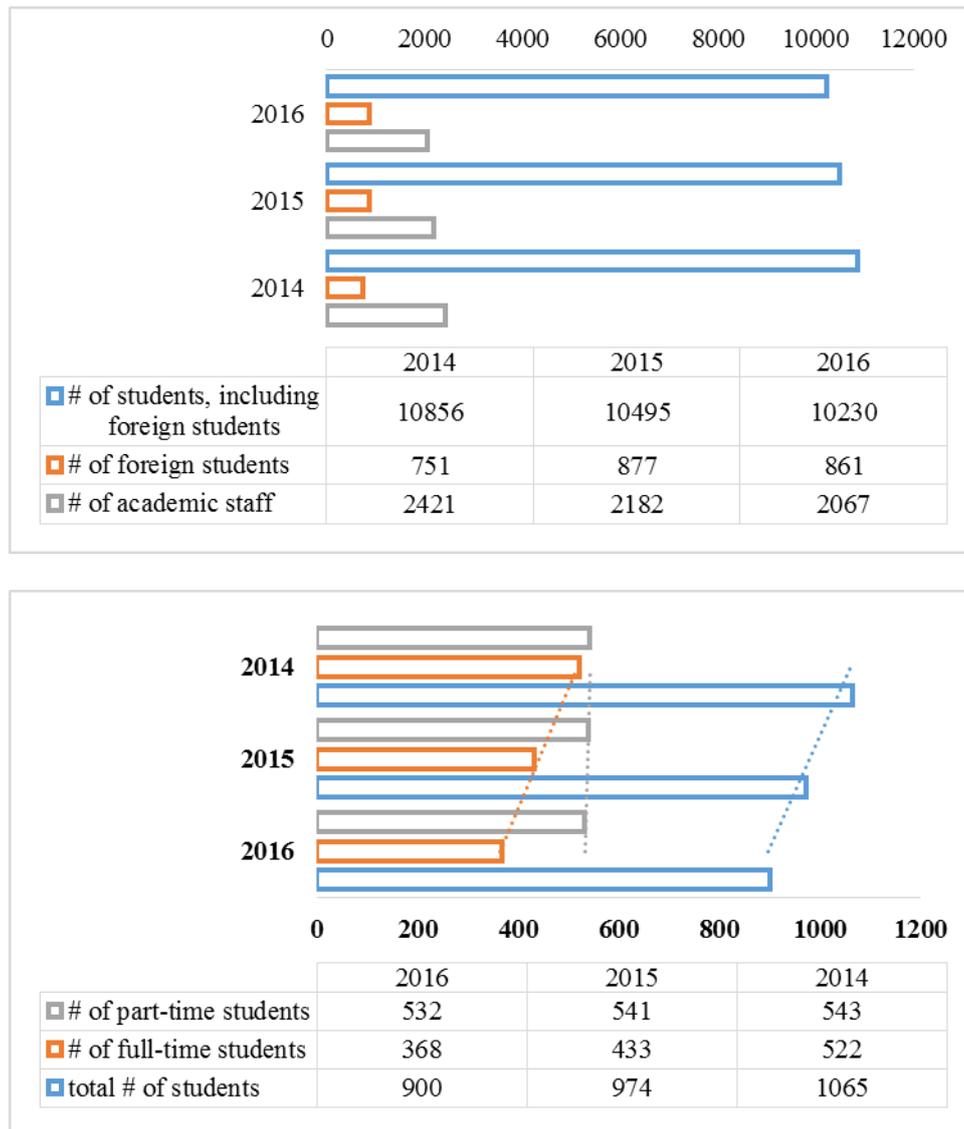


Figure 1. Number of users

The college has more than 170 employees. The college staff consists of 1) academic personnel (professors, lecturers or other) 2) personnel that gives out academic help to students 3) other administration staff.

Information and communication infrastructure

Kaunas University of technology has its own hybrid infrastructure. The infrastructure combines local university infrastructure with third-party Microsoft corp. public cloud e-services with composition between the two platforms. A simplified view of KUT hybrid architecture demonstrates Figure 2. VMware and Citrix solutions are used for flexible management of the hybrid KUT infrastructure.

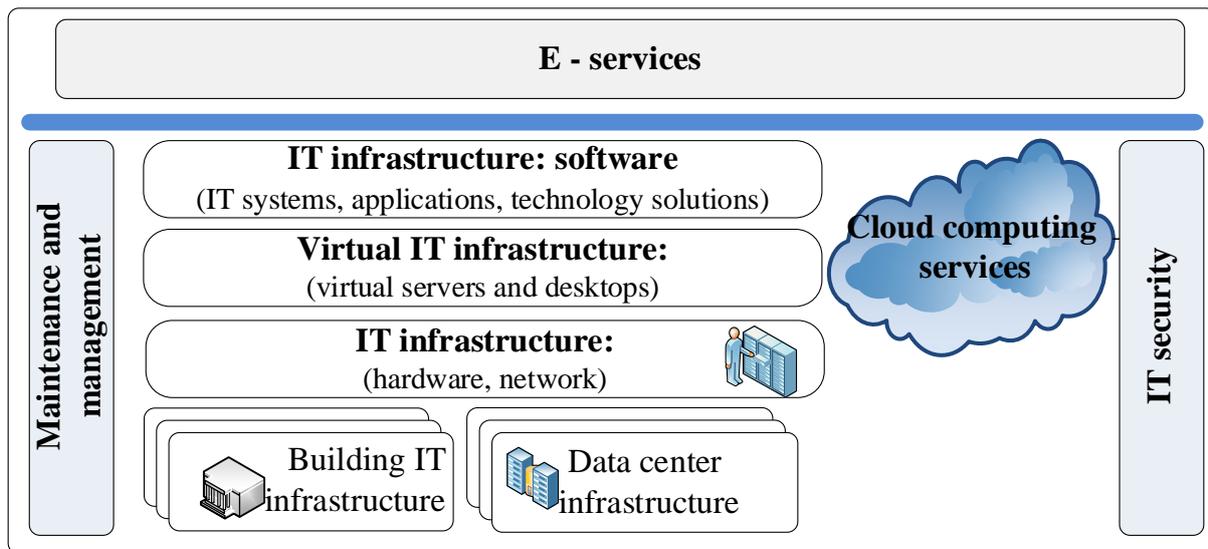


Figure 2. **Hybrid infrastructure of Kaunas University of technology**

The architecture of the hybrid cloud presents three layers:

- Physical layer includes the physical infrastructure of the system. The infrastructure includes computers, networks, routers, switches, hard disks and other physical component. In the layer are located facility means, such as heating, ventilation, electricity and other components.
- Virtual layer involves virtual machines used within the system. There are three types of virtualization solutions: virtual machine (VM), virtual desktop interface (VDI) and virtual applications (VApps). VM virtualizes physical machines in order to provide functionality of a physical computer. VMware solutions allow managing the virtual machines. VDI hosts a virtual desktop system on a centralized server in a data centre and provides each user with personal own desktop that can be customized like a traditional physical desktop. Citrix solutions provide many virtual desktops connecting to a terminal server. VApps component provides self-service programs while working in a virtual environment.
- Software layer. The highest layer reside IT systems, applications and other technology solutions.

KUT has implemented a Single-Sign-On (SELF) and Identity Management System solution (IMS). The purpose of the systems is to manage and administer institutional identities. Staff and students are provided with login credentials that are valid for the KUT e-services. Once the new user registers, the login name and the password are valid for all the services provided by the KUT network.

Virtual Desktop Infrastructure

Kaunas University of Technology owns the Virtual Desktop Infrastructure (VDI). The infrastructure provides a virtual computing environment to the staff and students in numerous training courses and research projects. Figure 3 illustrates the service infrastructure. The VDI structure is implemented using Citrix solutions. Citrix provides a complete virtual app. and desktop solution. It provides persistent Windows or Linux fully personalized desktops that can be customized to the users' needs anywhere on any device. Citrix Xen Desktop server manages the interconnection of users with the applications. This server comes out as a controller, which gives the user the right virtual environment, access rights to applications and so on. Another server (at this moment there are three servers Citrix-server app.) is running application programs (MS Office, MathCad, MatLab, etc.).

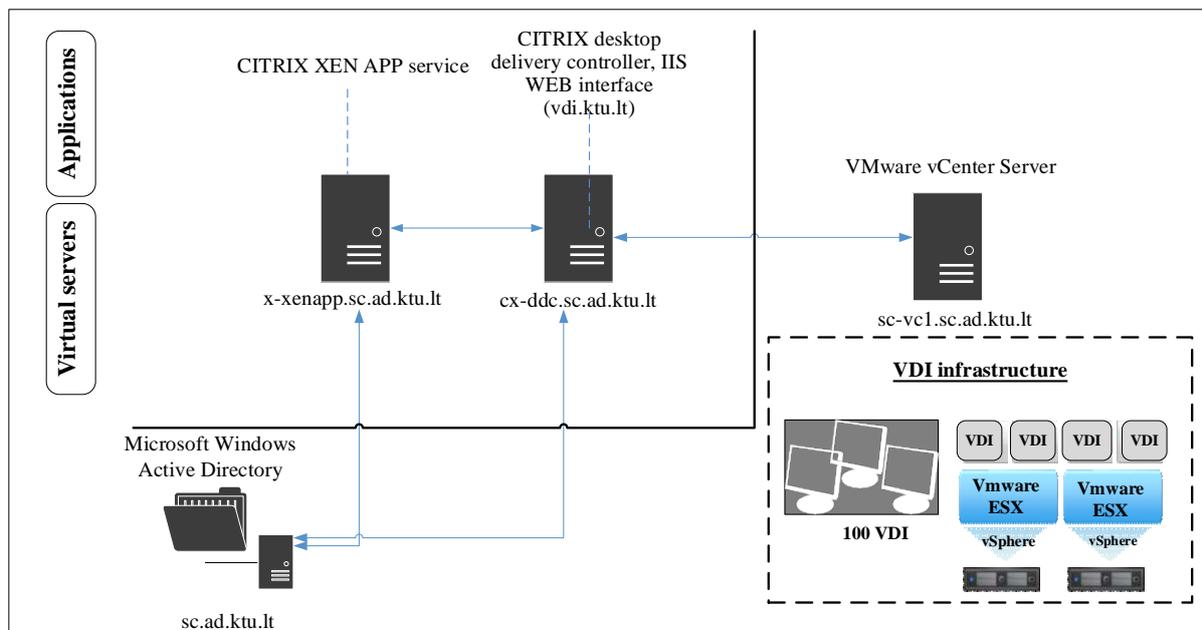


Figure 3. Solutions of VDI

Additionally, in the VDI structure are implemented administrator tools that help to manage users who are invoked the virtual services. The system administrators manage users when working with virtual resources and, is possibility to disconnect the users if they are not using resources for their work (for example, users are downloading torrents, etc.).

Use case analysis showed that Kaunas University of Technology is running its own hybrid ICT infrastructure. The infrastructure combines local university infrastructure and third party Microsoft corp. public cloud services. VDI is

implemented in hybrid KUT infrastructure. The infrastructure provides an opportunity for students to work with virtual desktops and a range of applications like MathCad or MatLab that are not normally available on their home computer. As this service is installed in KUT, the possibility of outsourcing the service is not discussed in the article.

The use case analysis of Marijampole College showed that the higher school has a low number of students, from which the bigger part are studying part-time. A big part of the users is changing. Equipment is not be fully used or it just be used for short period. It is lack of ICT equipment to provide qualified teaching service. MC users do not have VDI opportunities.

Cost Accounting Decision

The part of article discusses the VDI outsourcing possibilities in Marijampole College. Outsourcing is defined as purchasing a service from an outside vendor rather than producing the service in Marijampole College. The decision to outsource certainly considers reducing costs as a goal. If you can get the same service from outsourcing for less than producing the same service in Marijampole College, why not?

Author of the article (Blue, 2013) suggested evaluating four main parameters when making an investment decision: hardware, software, connection services, and personnel:

- 1) Computers, monitors, servers, printers, computer network adapters, and smart devices are so called hardware. In the process of assessing hardware budget, it is essential to evaluate depreciation, lease, technical maintenance, and upgrade expenditure. Moreover, it is important to take into account electricity costs of running the equipment as well.
- 2) While assessing a specific software it is necessary to pay attention to the aging of programs, required updates, possible changes, maintenances, and license costs.
- 3) In the evaluation of ICT services, it is important to determine website development, maintenance and safety expenses. In fact, it might require substantially greater investments than expected to implement a reliable safety environment online.
- 4) The process of setting up an IT specialists' budget necessitates accounting for salary, teaching, and tools charges.

Answering the question “when it is more economical to invest into the private ICT infrastructure and when it is more worth outsourcing it as a cloud service”, administration of Marijampole College must evaluate the facts:

- 1) MC has a low number of students, from which the bigger part are studying part-time.

- 2) A big part of users is changing.
- 3) Computers are not fully used or just for short period.
- 4) It is not enough of IT equipment to provide qualified teaching service.

The costs analysis was executed based on the BALTNETA (2011) calculation method, which involved all four facts about MC, discussed above, and compared expenditure for constituents of conventional computer classes and VDI cases.

The outsourcing decision involves a variety of costs factors. In the case of conventional computer classes, the Total Cost includes the sum of all direct and indirect costs. The direct factor includes Investment costs and Operational expenditure costs. The Investment costs are used to acquire hardware and software packages. The Operational expenditure costs are spent on electricity, salaries of IT administrators, maintenance, safety and data loss prevention and so on. Indirect costs comprise of expenses incurred due to an unexpected failure of hardware, downtime loss in time, deadlines overdue by the service providers etc.

The calculations are made for 20 and 40 conventional computers in the MC. Computers are installed with the Windows operating system and a free Office tools package. The local IT administrator maintains computers workspace in the institution.

In the first case of a conventional computer classes the Investment costs consists of funds needed to acquire computers, operating systems, and office tools. The Operational expenditure costs account for maintaining computer systems, safety insurance and electricity consumption.

In the second case of VDI outsourcing, the Total Cost is calculated with Thin Clients including. Therefore, there are no investment costs. Staff and students can also use devices that now are in College. Having in mind that there are no investment costs in the VDI outsourcing scenario, the Operational expenditure costs comprises of VDI workspace lease and electricity charges only. Outsourcing of VDI by a third-party service provider is typically based on a monthly subscription fee model.

The calculations showed the savings over the period of 5 years (Figure 4). The case of Outsourcing of VDI saves a significant amount of funds spent on IT hardware and software each year.

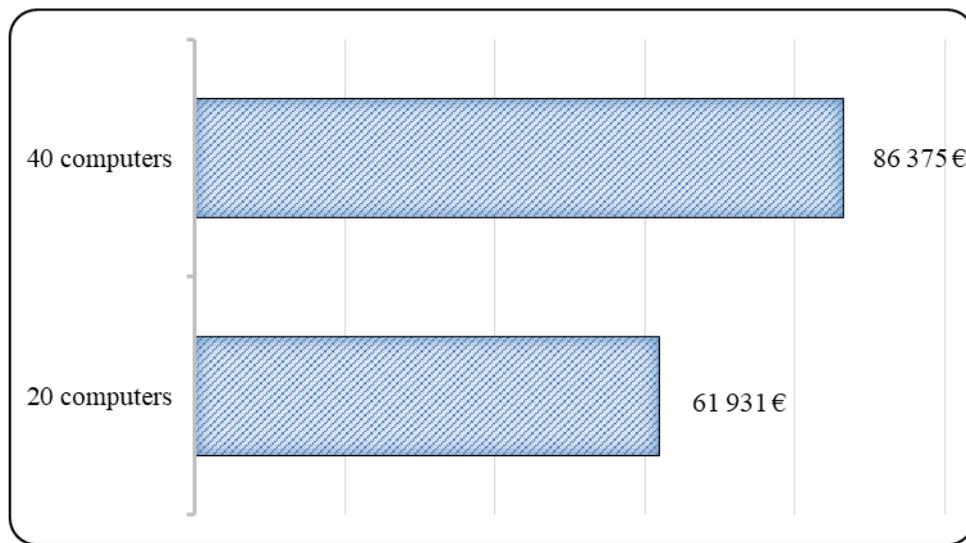


Figure 4. Savings over 5 years

Conclusions

Outsourcing VDI would allow to have a remote access for the Marijampole College's students and staff to the virtual desktop and other application at the college premises and at home. In addition, it would help to save a significant amount of funds spent on IT hardware and software each year.

Since VDI grants options of remote, modular, part time and continuous teaching of individuals and other members of labour market, the service is expected to contribute towards increasing the overall number of students.

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