CLOUD COMPUTING TECHNOLOGIES FOR GREEN ENTERPRISES

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Abstract. Nowadays, enterprises are encouraged to develop greener solutions. Regulations is getting stronger and stronger regarding the reduction of emissions, energy, water consumption or waste. Information technology plays a vital role in every business. Enterprises use information technologies to run their operations, manage their data, collaborate, communicate, and make decisions. Cloud computing technologies could help companies adopt much greener business practices. This paper examines how cloud computing technologies could help enterprises to become greener, analyses the use of cloud computing services by enterprises, analyses the implementations of green IT attributes in the cloud computing.

Keywords: green enterprises, cloud computing, green cloud computing

INTRODUCTION

Information technologies play an important role to business's daily operations and success. They help enterprises in automating their processes and their systems to target objectives, generate revenue and reduce inefficiency of their work. However, information technologies consume a lot of energy and create carbon emissions, making information technologies an important area where enterprises can focus their sustainability efforts (Naim, 2021).

As sustainability becomes more important to businesses every day. Cloud computing is a way for enterprises to become greener. It enables the transition towards a more sustainable business model, brings energy savings up and carbon footprint down. Cloud computing itself is a much greener alternative to individual data centers with lesser number of servers being used and cloud data centers being far more efficient than those of traditional thereby reducing the carbon impact (Jayalath et al., 2019).

Data centers are the heart of cloud computing and running thousands of server-side workloads, data storage and large scale of data and scientific processing. However, large data centers consume hundred megawatts of electricity (Jayalath et al., 2019). To achieve energy efficiency, reduce emissions, and waste, a variety of methods have been proposed in cloud computing.

The objective of the research is to review the main types of cloud computing services, examine how the cloud computing helps companies to reach their sustainability goals, present the results of analysis of use of cloud computing services by enterprises, analyse the implementations of green IT attributes in the cloud computing.

Research methods: analysis of scientific literature, data analysis.

The rest of this paper is structured as follows. Section 2 gives an overview of types of cloud computing services. Section 3 presents analyses of benefits of cloud computing services for green enterprises. Section 4 presents use of cloud computing services in enterprises according to results of data analysis. Section 5 gives an overview of green computing. Finally, Section 6 presents conclusions.

TYPES OF CLOUD COMPUTING SERVICES

Cloud computing is a general term for the delivery of hosted services over the Internet. Cloud computing models are generally separated into Software as a service (hereafter – SaaS), Infrastructure as a service (hereafter – IaaS) and Platform as a service (hereafter – PaaS).

• SaaS is a type of cloud computing services that provides a user an opportunity to achieve application through networks from various clients such as web browsers, and mobile phones. This model eliminates the need to install and run the application on the customer's local computers. SaaS offers already created applications running on a Cloud infrastructure such as: web-based email, alternatives of typical office, ERP, CRM and other applications. Users do not need to take care of the installation, maintenance, updated and licenses of the software (Sharm et al., 2020).

• IaaS is a type of cloud computing that provides virtualized computing resources over the internet. This type of services is also called virtual computing. In case of this cloud computing service, common infrastructure of computers and their systems is offered as a service. So, this service allows using not only software but also technical equipment, computer networks or other resources. Resources are distinguished

depending on user's needs. In case of necessity a user can increase or decrease possibilities of service resources. The users do not manage or control the underlying cloud infrastructure but have control over operating systems, storage, deployed applications, and possibly limited control of select networking components such as firewalls (Elsonbaty, 2018).

• PaaS is a type of cloud computing that offers infrastructure possesses a great variety of application components which allow working with programming tools, creating new modules, and improving the existing ones. With a help of platforms users can create and test applications adapted to particular actions. The users do not manage or control the underlying cloud infrastructure, including network, servers, operating systems, or storage, but have control over the deployed applications and possibly application hosting environment configurations (Elsonbaty, 2018).

BENEFITS OF CLOUD COMPUTING SERVICES FOR GREEN ENTERPRISES

P. Bajdor (2018) emphasize that cloud computing solution may bring some significant effects, not only such as cost reduction on IT maintenance, no need to buy a software, applications consolidation, cut back on system software, easy integration, no time and money needed for updates, easy access to date from different computers and speed up business development, but also may cause that the company will become more „sustainable" or act in a more „sustainable" way. Cloud computing makes a positive contribution to sustainability:

• **Cloud computing reduces paper waste**. It has dramatically reduced the need to create physical documents. Documents and files can be stored and shared in the cloud, improving energy efficiency as well as security, as duplicates can be created easily in a backup server.

• **The cloud computing saves the energy**. According to studies conducted by Google, business can save around 60-85 percent of their energy costs, simply by transferring into cloud. By locating computing infrastructure off-site, organizations do not have to run the dozens or hundreds of servers necessary to keep their business running, nor any of the equipment required to cool those servers.

• **The cloud computing reduces the carbon footprint.** According to Microsoft's report on the carbon benefits of cloud computing, business can reduce the carbon footprint, adopting cloud computing solutions. Small businesses can reduce their carbon emission by 90 percent, medium sized companies can reduce their carbon footprint between 60-90 percent while large enterprise have decreased their carbon footprint approximately between 30-60 percent.

• **The cloud computing reduces electronical waste.** By switching to cloud computing, companies reduce their electronical waste. They reduce the amount of individual, on-site hardware needed, as the service is delivered through shared servers, which inevitably cuts down on the amount of equipment being disposed of, when it eventually expires. Cloud hosting companies utilize hardware more efficiently. They can host multiple applications and infrastructures per server. Cloud hosting providers purchase relatively small amounts of hardware and fully utilize their servers, storage devices, and networking hardware before disposing of them.

In summary, it can be said that cloud computing is a real tool, which may help for enterprises to be more sustainable. Cloud computing facilitates a business case for a sustainable approach.

USE OF CLOUD COMPUTING SERVICES IN ENTERPRISES

The cloud computing is revolutionizing the IT industry in many ways. The sustainability benefits of cloud computing, it's positive impact on the environment is just one of its many positive attributes. To find out how cloud computing services is used by Lithuanian (hereafter – LT) and European Union (hereafter – EU) companies, a data analysis was carried out. Data from Eurostat, the statistical office of the European Union, Information Services Group and Lithuanian Department of Statistics are used for data analysis.

After performing the data analysis, it was found that, cloud computing usage in EU and LT enterprises grew rapidly over the last few years (see Figure 1). In 2020 it stood at 36 percent in EU enterprises (31 percent in LT enterprises) and in 2021 at 41 percent in EU enterprises (34 percent in LT). Over the last two years, the highest increase in cloud computing usage was observed in large enterprises.
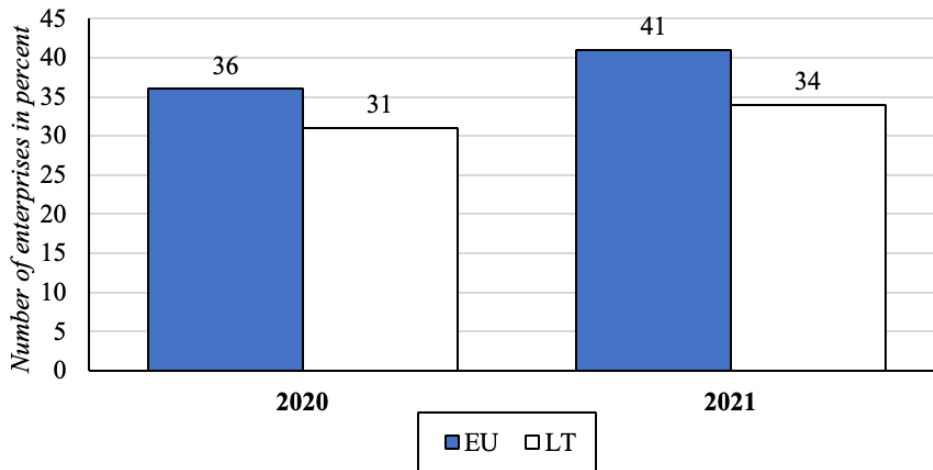
Figure 1. **Use of cloud computing in enterprises**

In 2021, 42 percent of EU and 34 percent of LT enterprises used cloud computing. SaaS was the most popular type of cloud computing services in 2021 (see Figure 2). SaaS solutions were used by 94 percent of EU and by 93 percent of LT enterprises that reported using cloud computing. Cloud users in businesses use IaaS services without owning the physical infrastructure and responsibility of maintenance. IaaS solutions were used by 74 percent of EU and by 63 percent of LT enterprises that reported using cloud computing.
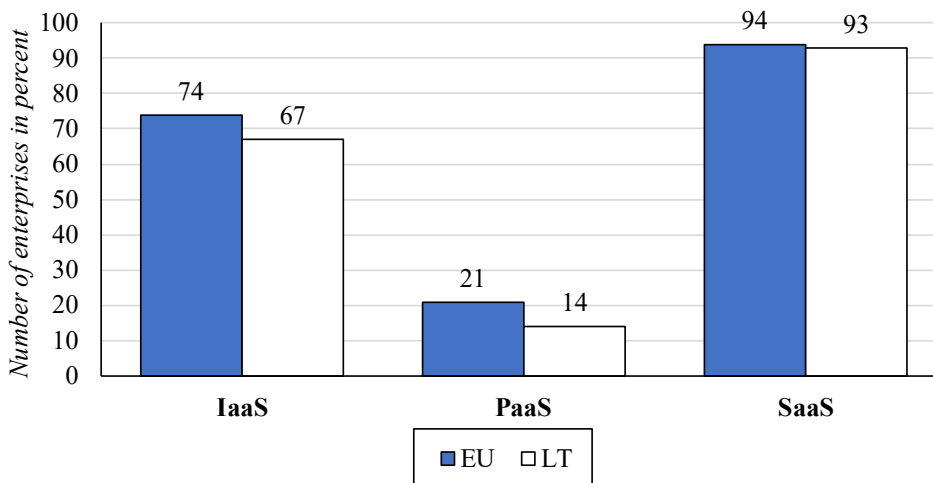

Figure 2. **Use of cloud computing in enterprises by type of services in 2021**

Cloud users in businesses use SaaS services without installation, management, and licensing needs. In 2021, the use of cloud computing for e-mail and storage of files is still predominant in EU and LT enterprises (see Figure 3). Among EU and LT enterprises which purchased cloud services in 2021, more than half used cloud for office software such as word processors and spreadsheets and for security software. In addition, enterprises reported using the end customer software applications, for finances/accounting (48 percent EU and 46 percent LT enterprises), for managing information about their customers (customer relationship management – CRM) (27 percent EU and 17 percent LT enterprises) and for planning their processes and resources (enterprise resource planning - ERP) (24 percent EU and 13 percent LT enterprises).
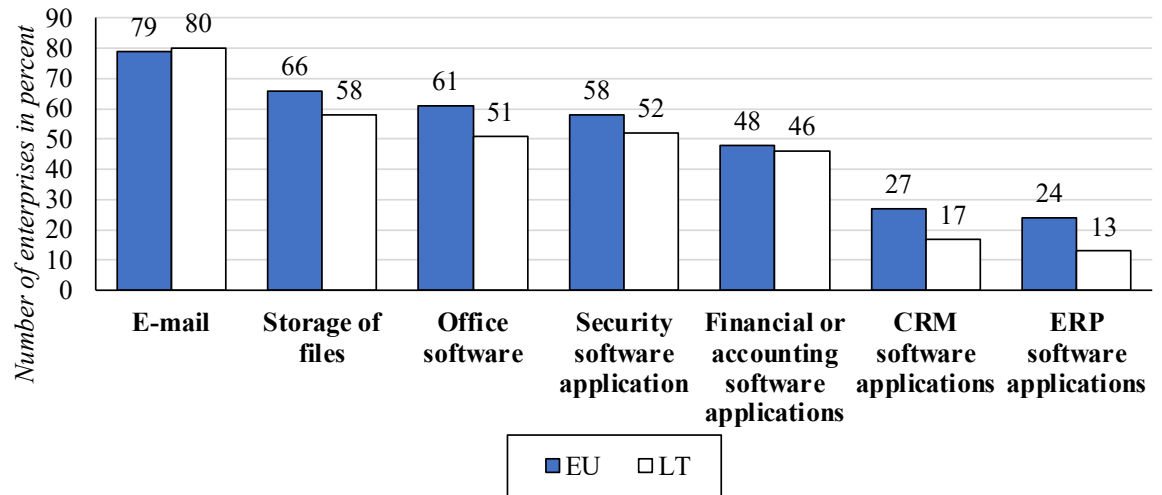
Figure 3. **Use SaaS in enterprises in 2021**

Enterprises use cloud computing to optimize resource utilization, save the energy, reduce paper waste, and build business models and market strategies that will enable them to grow, innovate and become more competitive.

GREEN CLOUD COMPUTING

Green Cloud Computing is also a cloud computing technique in which the resources and the energy are used very efficiently to reduce the effect of pollution and global warming on the environment, so that the goal of energy-efficiency of cloud data center improve, and the utilization of resources and electronic waste is reduced (Kumar et al., 2021). Different methods are used to achieve the goal of green cloud computing: save the energy, decrease the carbon footprint, reduce the consumption of resources (see Table 1).

Table 1. Comparison of Different Methods of Green Cloud Computing

No	Methods	Description	Effect
1	Virtualization technologies	Virtualization is the ability to run multiple operating systems on a single physical system and share the underlying hardware resources.	Effect of virtualization: • Rationalizes the usage of computing resources. • Save energy. More than 70 percent of the energy is saved (Kumar et al., 2021). • Reduce the environment footprint at all stages of the computer lifecycle by requiring less resources to do the same quantum of useful work.
2	Task Scheduling	Tasks scheduling are defined as a set of rules and policies used to assign tasks to the suitable resources (CPU, memory, and bandwidth) to get the highest level possible of performance and resources utilization (Cao et al., 2018). There are different algorithms for tasks scheduling in green cloud computing.	Effect of task scheduling: • Task scheduling algorithms for green computing can achieve an average up to 30 percent of energy savings (Cao et al., 2018). • Task scheduling algorithms for green computing can increase the resource utilization rate for about 25 percent (Cao et al., 2018). • Task scheduling algorithms for green computing can lead to higher profit and less CO_2 emissions (Cao et al., 2018).
3	Consolidation of Virtual Machines	Consolidation of virtual machines is a technique to reduce the number of active physical machines by migrating and consolidating the virtual machines into reduced number of physical machines. Consolidation of virtual machines can be performed either statically or dynamically (Abdelsamea et al, 2018)	Effect of consolidation of virtual machines: • Facilitating better use of the available data center resources (Abdelsamea et al, 2018). • Minimizing of energy consumption and improving of the quality of service (Abdelsamea et al, 2018).

CONCLUSIONS

Cloud computing helps companies to reach their sustainability goals by reducing paper waste, saving the energy, reducing the carbon footprint and electronical waste.

Cloud computing usage in EU and LT enterprises grew rapidly over the last few years. SaaS and IaaS are the most popular cloud computing solutions in EU and LT enterprises. The use of cloud computing for e-mail and storage of files is still predominant in EU and LT enterprises.

Cloud computing should adopt green IT attributes to reduce negative environmental impacts.

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