Review of Cloud Computing Framework for the Implementation of eLearning Systems

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Abstract

The rapid growth in Information and Communication Technology (ICT), combined with recent events such as the Covid-19 lockdown, has had a significant impact on traditional educational systems. Today, eLearning has become a widely accepted method for delivering educational services. As a result, the ICT infrastructure needed to be expanded to keep up with the increasing numbers of users, a wide range of learning services, and the growth of educational content. However, the volatile user load and the massive storage and transfer of rich data have led to a need for the effective utilisation of server-side system resources in providing eLearning services. Cloud computing offers a dynamic provision of virtualised resources, elasticity, scalability, pay-per-use and measured service with the ability to dynamically provision and de-provision computing resources as needed. In this paper, a review of cloud-based eLearning frameworks is conducted to identify the state of the art. Different frameworks for the implementation of cloud computing-based eLearning are identified and presented. Additionally, the review provides insights into the use of cloud computing in education, current challenges in eLearning implementation, deployment strategies, and the benefits of using cloud computing for eLearning implementation.

Keywords: *Cloud computing; eLearning; eLearning framework; Cloud computing-based eLearning.*

Introduction

Higher education institutions have rapidly adopted eLearning systems to enable them to deliver teaching and learning, even in the face of deserts like the pandemic or natural hazards (Harmon & Psaltis, 2021). This adoption has led to the development of educational technology, which, in turn, has driven the rapid advancement of technology-based learning tools and channels. These developments have necessitated growth in various dimensions, including system complexity, storage requirements, security and interface designs. For instance, the Enterprise Resource Planning (ERP) system for academic institutions in the year 2000 is not as sophisticated as the ERP of 2020, both in terms of value and functionality. The swift integration of technologies and platforms that match the complexity of ERP systems has taken a prominent place in academic settings.

The application of cloud computing has witnessed significant growth and adoption across various industries and organisations in recent years. This is due to the benefits associated with its adoption – scalability, cost efficiency and accessibility. Cloud computing enables businesses to rapidly deploy and scale applications, allowing them to meet evolving customer demands and adapt to changing market conditions more effectively (Kitchenham, 2009). One of the driving forces behind the widespread adoption of cloud computing is the increasing demand for digital transformation. Organisations are embracing

cloud technologies to modernise their IT infrastructure, improve operational efficiency, and enhance their ability to innovate. Cloud computing offers a flexible and agile platform for businesses to develop and deploy new applications, leverage advanced analytics capabilities, and harness emerging technologies such as artificial intelligence and the Internet of Things (Garcia, 2015).

Another driving force is the need for cost optimisation. Cloud computing allows organisations to shift from a capital expenditure model to an operational expenditure model, eliminating the need for significant upfront investments in hardware and software. With cloud services, businesses can scale their infrastructure up or down based on their requirements, paying only for the resources they consume. This pay-as-you-go model enables cost savings and allows organisations to redirect their IT budgets towards strategic initiatives (Kitchenham, 2009). Furthermore, the COVID-19 pandemic has accelerated the adoption of cloud computing. As remote work became the new norm, businesses heavily relied on cloud-based collaboration tools, virtual desktops, and cloud infrastructure to ensure uninterrupted operations and enable remote access to critical applications and data (Kitchenham, 2009). Cloud computing provided the scalability and flexibility needed to support remote work arrangements, enabling organisations to maintain productivity and continuity during challenging times.

Cloud computing deployment models have been recommended for academic solution deployment by various researchers (Mell & Grance, 2011; Bora, 2013). These models illustrate how cloud environments can be used for diverse situations (Malik, 2018). They categorise cloud deployments as private, public and hybrid (Alli, 2020; Garcia, 2015). The private cloud deployment model is managed by an organisation or enterprise with a private network (Aljenaa, 2011). The private cloud model offers superior security compared to the public cloud model, which is accessible to the public. Clients access services through the internet and pay for what they use. When comparing security between the public and private clouds, the private cloud tends to have more enhanced security mechanisms (Malik, 2018). Examples of public clouds include email, Google App Engine and Microsoft Azure, among others. The hybrid cloud combines private, public and community cloud models.

Aljenaa (2011) argues that different activities involving a high level of security should be managed using the private cloud, whereas those that are less critical could be achieved through the use of the public cloud. The community cloud is a type of cloud infrastructure where services are mainly accessed by a specific community of end users from a particular organisation that shares common concerns, such as mission, security requirements and others (Mell & Grance, 2011).

The service model in cloud computing is another crucial concept that allows customers to connect to the cloud. It is achieved through using services that provide the building blocks on which cloud computing is based. The major three service models in cloud computing include Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). Authors (Bora, 2013; Malik, 2018) describe the SaaS model as one that allows clients/customers to access software via the internet. This means that there is no need for software installation on different personal computers (PCs). In Aljenaa (2011), the merits of using such a model were identified. For example, there is no need for software maintenance and reduced support. Microsoft Office 365 and Google Workspace applications are some of the offerings that provide such services. PaaS is a service model that provides the capability to manage the entire application development lifecycle, allowing developers to execute all the processes involved in software development, including design, implementation, debugging, testing and deployment operations. The aim of this research is to examine the importance of eLearning implementation with cloud computing. The objectives are to i) review in order to identify the challenges confronted by higher education institutions when implementing eLearning systems based on cloud computing; ii) use an exploratory survey to gather related information from stakeholders in the field of eLearning; and iii) provide recommendations based on the analysis of the stakeholders' inputs. The other sections of this article are arranged as follows: related research to this work is presented in section 2; while section 3 describes the methodology adopted; section 4 is used to discuss the results of this review; and section 5 concludes the article.

Related Literature

In the global eLearning framework, Badrul (2010) posits that eLearning should encompass every aspect of actions and steps taken during the design of the eLearning process. The author suggests that the global eLearning framework should include components such as pedagogy, technology, interface, ethics, institutional support, resource management and evaluation. All these components are vital for the effective implementation of an eLearning system. This eLearning, however, was not cloud computing-based foreseeable.

Various eLearning frameworks have been implemented in cloud computing. For example, the papers in Alli (2020) and Garcia (2015) demonstrate how to adopt eLearning systems on the cloud platform. The paper, however, lacks implementation strategy . The authors in Kitchenham (2009) developed a comprehensive model that provides a holistic picture and identifies different levels of success related to a broad range of success determinants. This research model was empirically validated by fitting the model to data collected from 563 students engaged with an eLearning system in one of the UK universities through a quantitative method of Partial Least Squares – Structural Equation Modelling (PLS-SEM). The results show that users perceive usefulness and satisfaction.

The authors (Qian et al., 2009) noted that cloud computing plays a vital role in resource and service delivery, emphasising the importance of building and deploying efficient eLearning systems on the cloud. Many eLearning systems usually overlooked policy, storage and general management of eLearning systems in the cloud, as explained in Soh et al. (2020). Research in Harmon and Psaltis (2021) presented an efficient eLearning framework based on cloud computing. In this framework, a model with components based on dynamic data centres with operational management, security tests and environmental cloud software platforms was presented. This study, however, did not provide a blueprint for implementation.

The purpose of Etro (2014) is to discuss the effectiveness of cloud computing in eLearning and to explore the potential challenges associated with implementing eLearning systems. Cloud computing is promoted as a possible solution to these issues. The article proposes a paradigmatic model for cloud-based eLearning using the diffusion of innovation and fit-viability model, along with factors influencing information culture. In addition, the author in Aljenaa (2011) presents the development of an instrument to evaluate the adoption of cloud-based eLearning based on two vital learning aspects: the approach of a systematic review and the interaction among concerned experts' points of view. This instrument was designed to measure the adoption factors for cloud-based eLearning as perceived by higher education institutions (HEIs).

The study in Jasam (2015) examined the factors affecting the behavioural intention, the direct influence of habits, the beneficiary motivation, and the favourable conditions for the acceptance of using eLearning-based cloud computing. The study gathered data from a survey of 696 students and applied the extended UTAUT model for adoption. The estimated results from the linear structural models show that there are six determinants of accounting students' behavioural intention, with performance expectancy having the strongest impact, followed by effort expectancy, price value, facilitating conditions, hedonic motivation and social influence.

The author in Alghamdi (2018) conducted a survey with 974 participating students from five Indonesian HEI on eLearning with the cloud. An extended Technology Acceptance Model (TAM) with facilitating conditions as the external factor was implemented as the theoretical framework of the study. An analysis method through PLS-SEM was employed to measure and assess the proposed model. The study conducted by Mell and Grance (2011) presents current research issues and future progress in eLearning in HEIs in the wake of the COVID-19 pandemic from 2019 to 2020 through the Web of Science (WOS) database. The bibliometric review provides essential insights for researchers to identify the most influential publications and determine the fundamental structure.

An eLearning framework based on cloud computing was introduced in Srivastava and Khan (2018), known as the BlueSky cloud framework. The architecture and core components of this framework are explained, where physical machines are virtualised and allocated on-demand for eLearning systems. The framework combines traditional middleware functions, such as load balancing and data caching, to serve

as a general architecture for eLearning systems. The proposed system addresses the challenges related to scalability and availability. The paper in Motahari, Hamid, Singhal and Stephenson (2009) proposes a cloud computing data storage model for eLearning systems to enhance storage capacity and utilise resources for universities in developing countries. This review suggests the existence of various eLearning systems with cloud computing. Despite this fact, organisations and higher learning institutions have not keyed in to the adoption of the cloud for eLearning systems due to some factors like cost implications, privacy concerns, latency and bandwidth.

Methodology

This paper is based on a review of academic literature related to the implementation of eLearning with a cloud computing database. The study conducted a search of literature related to the cloud base eLearning implementation from electronic academic databases. Different criteria were used to select the articles that were most relevant to the study. Only articles that were less than 15 years old were considered relevant. Review papers which address eLearning and eLearning with cloud computing were considered in the study. The initial search was conducted at the beginning of February 2023 in popular computing electronic databases. The electronic databases used included Science Direct, IEEE Xplore, Google Scholar, Scopus and Springer. Table 1 contains examples of the list of electronic databases that were used to perform a literature search. Different keywords were used in order to extend the search and to ensure that the study covered as much related literature as possible. The PRISMA framework used for analysis consists of four stages, which are identification, screening, eligibility and inclusion. Figure 1 shows the PRISMA framework with four stages. The stages of the framework followed in this research were discussed in the following subsections:

Table 1: Sample of electronic databases used during literature search

Name of Database	Access Method	Website
Scopus	Online Search	https://www.elsevier.com/solutions/scopus
Science Direct	Online Search	https://www.sciencedirect.com/
IEEE Xplorer	Online Search	https://ieeexplore.ieee.org/
Springer	Online Search	https://www.springer.com
Google Scholar	Online Search	https://scholar.google.com/

Search keywords

The literature search approach proposed by Kitchenham (2009) was used in this study. Hence, to determine the most appropriate search phrases, the core search terms were carefully chosen. The following terms were used to search the relevant material in some renowned academic archives using the review specified goals: "eLearning", "Cloud computing" "Cloud computing with eLearning" and "eLearning implementation". This search provided a number of articles used by this research to conduct the review.

Record extraction

In this phase, 120 data were extracted based on the originality of peer review articles and conference papers. Other categories were excluded; only selected article in the English language in the field of eLearning systems based on cloud computing were considered between 2009 and 2022. The extracted papers were only from African and Europe countries and all other countries were excluded.

Explicit inclusion and exclusion criteria

The study employed a number of principles in the selection of articles in order to maintain a direct focus on the subject matter and avoid any form of bias in the review of papers. The principles are described in Table 2.

Table 2: Inclusion/exclusion criteria

S/N	Inclusion criteria	Exclusion criteria
1	The research focused on the implementation of eLearning with cloud computing.	The study did not focus on cloud computing alone.
2	The topic was peer-reviewed and published in scholarly publications or conference papers.	The topic was not peer-reviewed or published in any academic journals or conference papers.
3	The research paper was written in English.	The study was not written in English language
4	The articles were either surveys or research papers that were published.	The pieces were not surveys or research studies, but rather news flashes or magazine articles.

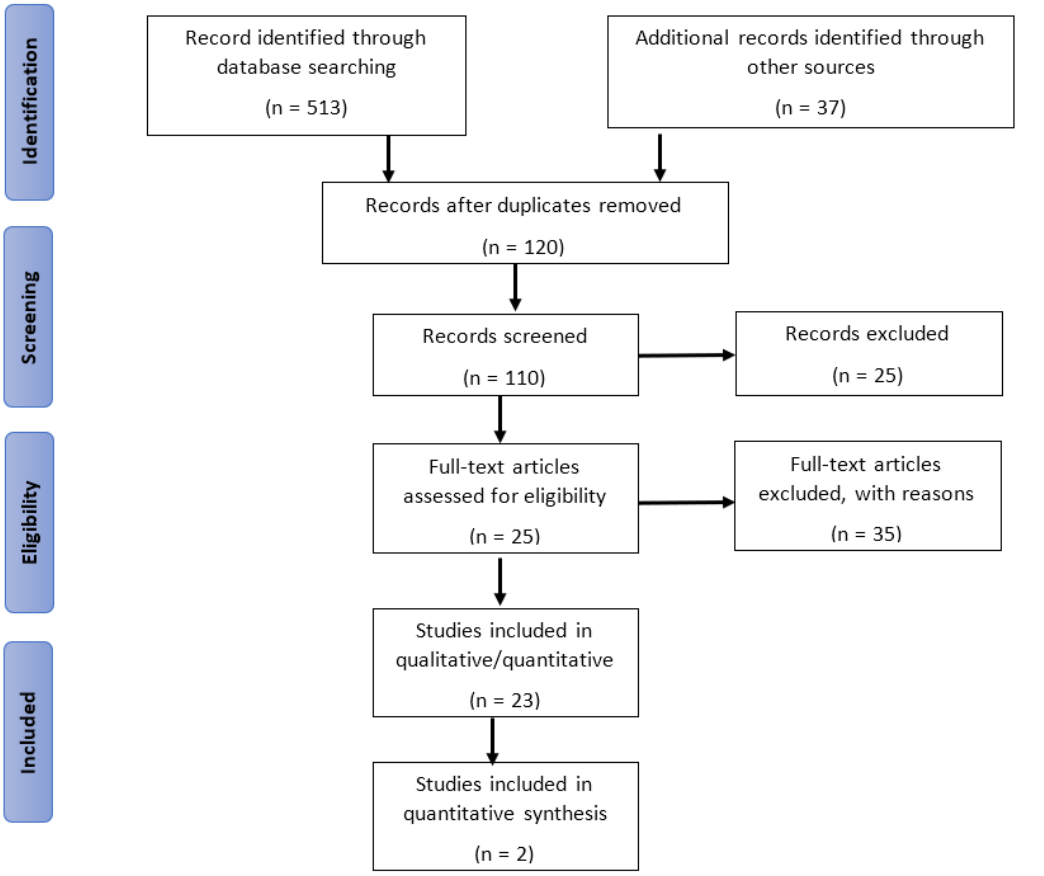

Figure 1: PRISMA framework

Source: MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al [72]

Results

This results are presented based on the parameters represented in the PRISMA framework in Figure 1. In this figure, 513 articles were identified through database searching, and 37 additional records were identified through some other sources. The records left for analysis after the removal of duplicates are 120. One hundred ten (110) records were successfully screened, where 25 of the records were removed. Twenty-five (25) full-text articles were assessed for eligibility, where 35 were excluded with different reasons. Twenty-three (23) studies were included for quantitative and qualitative analysis, while only two studies were included in quantitative synthesis. The results in Figures 2, 3, 4 and 5 present the results of analysis of records based on the PRISMA framework, record identification, screening of records, eligibility of records and records inclusion criteria. The identified benefits based on the literatures are increased scalability and flexibility, cost-effectiveness, improved accessibility, and enhanced collaboration among learners and instructors. The benefits and challenges are presented in table 3.

Table 3: Benefits and challenges associated with cloud-based eLearning implementation

S/N	Benefits	Challenges
1	Scalability	Data security and privacy
2	Cost-effectiveness	Latency
3	Improved accessibility	Bandwidth
4	Enhanced collaboration	Compatibility issues with existing infrastructure
5	Flexibility	Connectivity and technical support and maintenance requirements

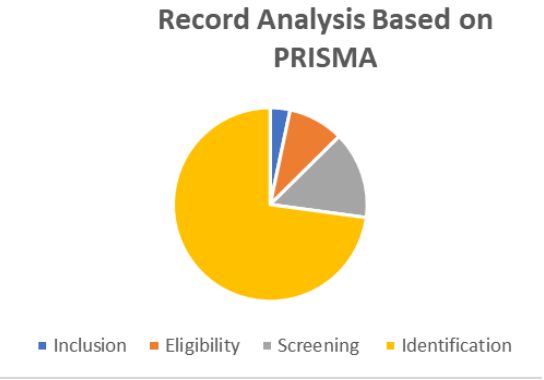

Figure 2: Analysis of records based on PRISMA framework

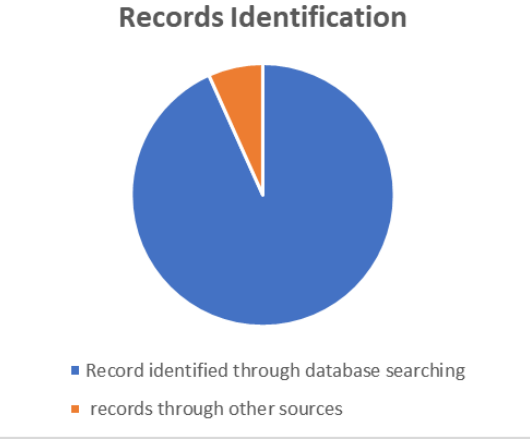

Figure 3: Identification of records

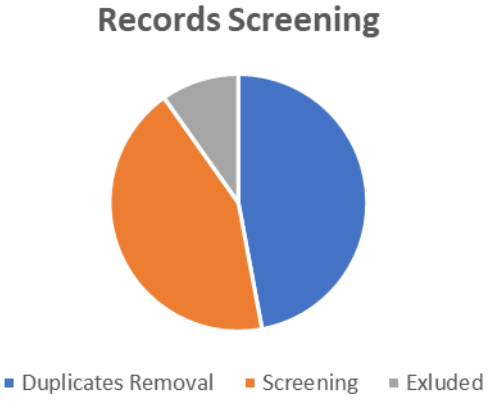

Figure 4: Screening of records

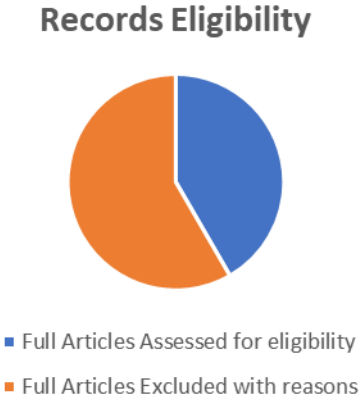

Figure 4: Eligibility of records

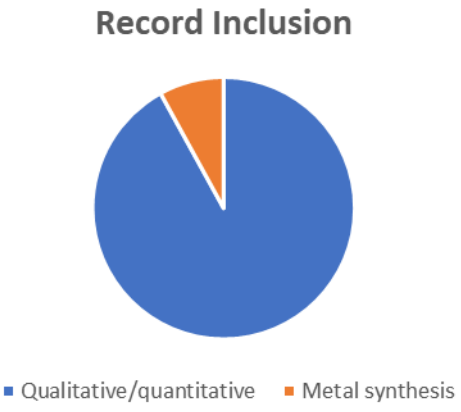

Figure 5: Records inclusion criteria

Discussion and Findings

The aim of this study was to examine the benefits of implementing cloud computing in eLearning systems through a comprehensive review of peer-reviewed academic publications spanning 2009 to 2022 as presented in Table 3. Out of a total of 550 articles gathered, 513 were identified through database searches, while the remaining 37 records were obtained from other sources. After removing duplicates, 120 records remained for analysis. Subsequently, 110 records underwent successful screening, resulting in the removal of 25 records for various reasons. Twenty-five (25) full-text articles were assessed for eligibility, leading to the exclusion of 35 articles for different reasons. In the inclusion phase, 23 studies were considered for quantitative and qualitative analysis, with only two studies were included in the meta-synthesis. Figure 1 provides a summary of the records identified during the process, following the PRISMA framework. In Figure 2, records identified through various sources are presented. Figure 3 depicts the records that underwent screening and those that were removed based on specific criteria. Figure 4 outlines the eligibility criteria used for record inclusion and exclusion; while Figure 5 illustrates the inclusion and exclusion criteria applied during the methodology stage. The review suggests the necessity of implementing eLearning with cloud computing based on its identified significance. After a thorough review of the relevant papers, several key findings emerged. Firstly, the study identified various benefits associated with implementing cloud computing in eLearning, including increased scalability and flexibility, cost-effectiveness, improved accessibility and enhanced collaboration among learners and instructors. Secondly, the study identified common challenges associated with this implementation, such as concerns about data security and privacy, latency, bandwidth, and compatibility issues with existing infrastructure, technical support and maintenance requirements, as well as the need for reliable internet connectivity. Addressing these challenges is crucial to ensure the successful adoption of cloud-based eLearning systems.

Conclusion

This study provides a review of the implementation of eLearning with cloud computing. Some of the publications examined involve the implementation of eLearning using cloud computing, while others discuss how eLearning can be effectively implemented with cloud computing and the advantages of using cloud computing as a database for eLearning. In the study, out of a total of 550 articles gathered, 513 were identified through database searches, while the remaining 37 records were obtained from other sources. After removing duplicates, 120 records remained and were used for analysis. Subsequently, 110 records underwent successful screening, resulting in the removal of 25 for various reasons. Twenty-five (25) full-text articles were assessed for eligibility, leading to the exclusion of 35 articles for different reasons. In the inclusion phase, 23 studies were considered for quantitative and qualitative analysis, with only two studies included in the meta-synthesis. The study was able to identify the benefits and challenges associated with eLearning implementation with cloud computing. The authors recommend implementing eLearning with a cloud-based database to enhance system effectiveness and efficiency. In addition, the study suggests including robust security measures, seamless integration with existing infrastructure, reliable technical support, effective data backup and recovery mechanisms, and ongoing monitoring and evaluation to optimise system performance.

References

Alghamdi F. A. (2018). An integrated cloud model for intelligent eLearning system. *International Journal of Applied Engineering Research*, 13(14), 11484–11490 [Online]. Available: http://www.ripublication.com

Aljenaa, E. (2011). *Toward an efficient eLearning system based on cloud computing.* Available: https://dl.acm.org/doi/abs/10.1145/2107556.2107569

Aljenaa, E. (2011). Towards an efficient eLearning system based on cloud computing. *Proceedings of the Second Kuwait Conference on e-Services and e-Systems.* https://dl.acm.org/doi/proceedings/10.1145/2107556

Alli, A. A., Mugigayi, F., & Cherwoto, A. (2020). Blockchain and fog computing: Fog-blockchain concept opportunities and challenges. In *Blockchain in data analytics*, Cambridge Scholars Publishing, pp. 75–101.

Badrul, H. K. (2010). The Global ELearning Framework. Stride Handbook 8. Elearning-Chapter5: Layout 1 1/6/2010 5:58 PM Page 42

Bora, U. J., & Ahmed, M. (2013). *ELearning using cloud computing.* No. 2, pp. 9–13.

Etro, F. (2014). The economics of cloud computing. *Cloud technology: Concepts, methodologies, tools, and applications*, 4 (August), 2135–2148. Doi: 10.4018/978-1-4666-6539-2.ch101.

Garcia, L. P. (2015). Edge-centric computing. *ACM SIGCOMM Computer Communication Review.* Doi: 10.1145/2831347.2831354.

Harmon, R. L., & Psaltis, A. (2021, May). The future of cloud computing in financial services. *The Essentials of Machine Learning in Finance and Accounting*, pp. 123–138. Doi: 10.4324/9781003037903-7.

Jasam, K. S. K. (2015). Cloud computing: A new era of IT opportunity and challenges. *International Journal of Science and Research (IJSR)*, 4(6), 756–759 [Online]. Available: https://www.ijsr.net/archive/v4i6/SUB155214.pdf

Kitchenham, B., Pearl Brereton, O., Budgen, D., Turner, M., Bailey, J., & Linkman, S. (2009, Jan.). Systematic literature reviews in software engineering – A systematic literature review. *Information and Software Technology*, 51(1), 7–15. Doi: 10.1016/j.infsof.2008.09.009.

Malik, M. I., Wani, S. H., & Rashid, A. (2018). Cloud computing-technologies. *International Journal of Advanced Research in Computer Science*, 9(2), 379–384. Doi: 10.26483/ijarcs.v9i2.5760.

Mell, P., & Grance, T. (2011). The NIST definition of cloud computing. *Cloud Computing and Government: Background, Benefits, Risks*, pp. 171–173. Doi: 10.1016/b978-0-12-804018-8.15003-x.

Motahari, N., Hamid, R., Singhal S., & Stephenson, B. (2009). Outsourcing business to cloud computing services: Opportunities and challenges. *JOUR.*

Qian, L., Luo, Z., Du, Y., & Guo, L. (2009). Cloud computing: An overview 1: Definitions of cloud computing. *IEEE International Conference on Cloud Computing*, pp. 626–631.

Soh, J., Copeland, M., Puca, A., & Harris, M. (2020). Microsoft Azure and cloud computing. *Microsoft Azure*, *1*, 3–20. Doi: 10.1007/978-1-4842-5958-0_1.

Srivastava, P., & Khan, R. (2018). A review paper on cloud computing. *International Journal of Advanced Research in Computer Science and Software Engineering*, *8*(6), 17. Doi: 10.23956/ijarcsse.v8i6.711.

Systems, A. I. (2002). The NIST definition of cloud computing, pp. 267–269. Doi: 10.1016/B978-0-12-804018-8.15003-X.