Designing a Framework for Implementing E-Learning Systems Utilizing Cloud Computing and Blockchain: A Case Study of Diyala University

Aymen Mudheher Badr[1], Qahtan M. Yas[2], Thaer M. Al-Hadithy[3] and Hafiz Gulfam Umar[4]
[1]*College of Medicine, University of Diyala, 32001 Baqubah, Diyala, Iraq*
[2]*Computer Science Department, College of Veterinary Medicine, University of Diyala, 32001 Baqubah, Diyala, Iraq*
[3]*Iraqi Sunni Affairs Taleemdeny - Education, 10001 Baghdad, Iraq*
[4]*Department of Computer Science IT, Ghazi University, 32200 Dera Ghazi Khan, Pakistan*
{aymen.m.badr, qahatn.myas}@uodiyala.edu.iq, thaer.mufied@ijsu.edu.iq, hahmad@gudgk.edu.pk

Keywords: E-learning Systems, Blockchain Technology, Information and Communication Technologies, Cloud Computing, Learning Management System.

Abstract: Integrating Information and Communication Technologies (ICT) into education has revolutionized the advancement and accessibility of e-learning in the modern educational landscape. However, poor infrastructure presents significant challenges for traditional e-learning, particularly in resource-limited areas like Iraq. This paper explores the role of cloud computing in overcoming these challenges and improving e-learning systems, focusing on the University of Diyala as a case study. A framework for a cloud-based e-learning platform architecture is proposed, based on Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) models, to provide scalable, cost-effective, and secure solutions. Blockchain technology and lightweight cryptography are incorporated into this framework to enhance transparency and security further. The integrated framework consists of several components, such as centralized cloud storage, virtual classrooms, and a Learning Management System (LMS), all supported by strong security protocols and adaptive resource allocation strategies. This research helps enhance e-learning systems in developing countries with a directional pathway for institutions that want to embrace digital transformation in education.

1 INTRODUCTION

The sophisticated transformation brought about by the developments in Information and Communication Technologies (ICT) has created a rebirth of the education system vis-a-vis its delivery and consumption process. Teaching is now slowly but surely complemented and sometimes replaced with e-learning platforms, which were unthinkable in a traditional setup where knowledge delivery occurred primarily through physical classrooms, printed textbooks, and face-to-face interactions. These development systems offer various benefits such as flexibility, improved accessibility, and interactive tools that enhance learning. However, this spiraled demand for e- learning recently posed momentous challenges, even in regions with feeble ICT infrastructure, like Iraq. Educational institutes in Iraq grapple with issues in the effective implementation of e-learning, due to a lack of ICT infrastructure, recurrent power blackouts, a lack of requisite technical capabilities for teachers and students, and fear of data security and privacy [1], [2].

These obstacles impede universities from creating smooth and impactful e-learning programs necessary in today's tech-savvy world. Some urgent dilemmas facing educationists now entail the hurried adoption of blooming technologies such as cloud computing and blockchain with lightweight encryption support. In this instance, cloud computing presents a scalable and affordable option to lodge e-learning systems, allowing these institutions to navigate infrastructural challenges by managing costs effectively [3].

Blockchain is the pillar of transparency and immutability of academic records while voicing the worries regarding trust and accountability [4]. Besides, lightweight cryptography guarantees security while performing efficiently even in resource-deprived environments [5]. It is thought

that these technological approaches, combined with innovative breakthroughs in security, accessibility, and reliability, provide the best chance for mild improvement of e-learning systems. It aims to provide far-reaching insight into the situation of e-learning platforms, especially challenges, being analyzed in detail in this research, which concerns the University of Diyala, based on recommendations from the recent research [6], [7].

Relevant research, regarding exploring cloud computing, blockchain technology, and lightweight encryption, has been reviewed. Various studies have concentrated on these approaches to trace effective data privacy and security measures for cloud systems [8], [9], [10]. With these techniques being integrated with the design of learning systems, including a mathematical model for resource allocation and an algorithm for dynamic resource scaling [11], [12], [13], a discussion of their prospective advantages, such as enhanced scalability, a better user experience, and improved transparency, has been offered. In addition, recommendations for macro program research are suggested to further curb their future investigation, thus broadening these solutions.

2 PURPOSE OF STUDY

One means of approaching the e-learning system is as a complete technological platform that is radically changing the way education is delivered and accessed. These systems offer an interactive digital platform on which learners and teachers can work interactively, access educational content, and collaborate in academic work, independent of their geographic locations. Their main strength is that they provide an opportunity to deliver educational resources and make them commonly available to learners anytime and anywhere, thus making it easier for students to gain access to and increase flexibility in learning. E-learning streamlines certain administrative activities that range from attendance, grading, and certificate printing, reducing the stress and workload on teachers while improving efficiency at the institution.

However, with these myriad benefits, considerable challenges come in implementing these e-learning systems, especially in developing nations like Iraq. In such settings, socio-economic challenges and infrastructural deficiencies severely hamper the uptake and effective use of these platforms. The process will involve closely examining and reviewing in detail the wide-ranging critical constraints facing the rollout of e-learning systems within the specific context of Iraqi society to develop a way forward.

2.1 Infrastructure Limitations

In developing countries, inadequate infrastructure poses an obstacle to the effective implementation of e-learning systems. In the case of Iraq, many educational institutions face serious constraints on hardware and software resources. For example, poor internet bandwidth greatly prevents regular access of students and instructors to online platforms, which interrupts the continuity of the learning process [1]. Besides, using outdated computing devices and having limited access to the cloud increases the disadvantage. According to [1], [17], such inadequacies in ICT infrastructure seriously undermine the scalability and reliability of e-learning systems. Similarly, Al-Mahouti et al. (2021) discussed challenges involving cloud computing implementation within an educational framework, emphasizing that several institutions have insufficient financial capabilities for modern technology solutions [2]. Because of the infrastructural barriers, there is an urgent need for new ways that would be effective in resource-limited settings.

2.2 Technical Expertise

Another key impediment is that there were not enough educators or students who had the technical skills to operate. The effective use of e-learning platforms generally requires some grasp of advanced digital tools like cloud-based services, online collaboration technologies, and, more often than not, multimedia content creation applications. Nevertheless, many teachers in Iraq have inadequate experience in using such technologies, which limits their ability to use e-learning systems [14]. Hussein and Halmi (2022) stress that [3] lack of adequate training programs for teachers and students is a huge impediment in implementing e-learning platforms. Kumar (2023) is also of the view that, along with addressing the infrastructural inadequacies, there is a need to enhance technical competence, as even the latest e-learning systems would be of no help if the end-users do not know how to operate them [5, 6]. Somehow, targeted training programs develop and intuitive user-interface designs facilitate the adoption process by lessening the complexity for all the stakeholders involved.

2.3 Power Supply Issues

Power cuts, therefore, have become a major hindrance to the sustained implementation of e-learning systems in Iraq. The disrupted supply of electricity foils virtual classes and access to digital learning resources; it generates immense psychological frustration for both teachers and students. The implications of erratic power infrastructure on e-learning platforms were examined in a detailed review of literature conducted by Burney and Alam (2023); it concluded that extended outages critically compromise overall effectiveness [7]. In light of these developments, offline capabilities must be integrated into e-learning systems to allow students to access and interact even when the electric supply or the internet is disrupted. These facilities play a crucial role in ensuring continuous learning accessibility and continuity in the education process.

2.4 Security Concerns

The management and transfer of sensitive educational information across digital platforms pose serious challenges with respect to data privacy and security. Hence, e-learning institutions need to strengthen their systems against any online attacks, including data breaches, unauthorized access, and data manipulations. Nazir et al. (2023) try to analyze these effects on cloud-based educational systems and strongly underscore the critical role of encryption mechanisms in safeguarding such sensitive information [8]. Correspondingly, Alim et al. (2023) advocate implementing lightweight encryption techniques for data protection in low-computational-resources environments [9].

With cultural apprehensions allows educational opportunities to create a culture receptive to technological advances.

2.5 Cultural Resistance

Cultural resistance against change remains a crucial barrier to e-learning thriving. While most higher education institutions rely on long-established traditional ways of learning, skepticism nonetheless continues on the pedagogical effectiveness of online learning in contrast to face-to-face instruction. Eze et al. (2023) [15] outline cultural dimensions contributing to this resistance, explaining how both teachers and students come to view digital platforms as cold or lacking rigor compared to traditional classroom settings. Alleviating such resistance will require deliberate advocacy for awareness, both about e-learning's advantages and the capability of e-learning to easily converge with traditional instructional practices.

The architecture of the proposed system includes different levels, such as the end-user level, the application level, the local server level, and the blockchain level. These levels are the ones responsible for the efficient management of data through all the stages for optimal performance and security. Figure 1 presents the main design of the e-learning system, which can be found at the University of Diyala.

3 PROPOSED A FRAMEWORK ARCHITECTURE

The proposed framework addresses the implementation of a theoretical architecture into a working e- learning system, suggested to solve the specific problems faced by Diyala University. In this section, the implementation is described through the development of the basic components, suggested integration of related technologies, and explanation of the various types of testing.

3.1 System Architecture

System architecture is very carefully designed to ensure smooth operation under severely resource-constrained conditions, with offline features, and includes comprehensive and resilient security mechanisms. The next presentation is the full overview of the important architectural framework.

In addition, Amer and Alnaja (2023) advocate blockchain as a spectrum of technology in providing transparency and UNCST to guarantee the accuracy of academic transcripts for building trust and accountability [4]. This way, the integration of all these advanced security techniques is bound to build users' confidence while preserving the reliability and integrity of education data on e-learning platforms.

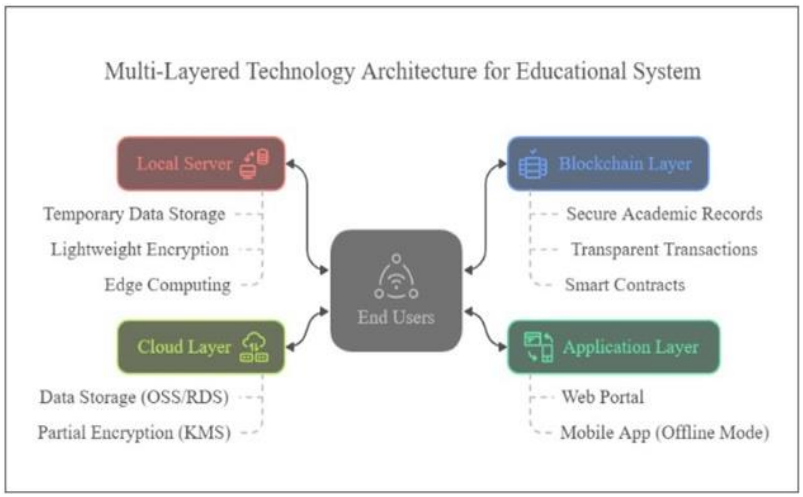

Figure 1: System architecture layers.

4 IMPLEMENTATION OF E-LEARNING SYSTEM

At the start, this layer is developed to be the basic interface for the end-user. The web portal is developed based on React.js, which is probably the most modern JavaScript library known to date for creating dynamic and interactive user interfaces. According to the developers, the mobile application is built using Flutter, a cross-platform, general-purpose framework that builds lightweight, scalable applications. Both the web portal and mobile app have offline functionality that allows users to access cached data and perform necessary tasks even in the absence of an internet connection. The mobile app implements local storage solutions like SQLite to cache commonly used data. The architecture of the proposed framework for the e-learning system has been illustrated in Figure 2.

Stage two saw the deployment of the local server through the Linux Ubuntu Server, which was chosen for its known reliability and efficient resource usage, as depicted in Figure 3.

Data handling was achieved through SQLite, which serves as the local database for temporary data storage, along with the running of lightweight encryption and thin-edge computing operations by means of Python scripts [16]. The server provisioned would position itself as the intermediary between the application layer and the cloud resources, allowing for local data processing in instances of internet jamming. This architecture not only allowed a reduction in latency but also reduced dependence on cloud resources, enabling adherence to certain core aspects of edge computing.

Phase three, the cloud layer, sees the various Alibaba Cloud services employed for their high scalability and cost-effectiveness. The Object Storage Service (OSS) serves to store multimedia files, including lecture videos and PDF files, while the Relational Database Service (RDS) handles structured datasets such as student profiles and attendance records. For the cloud to protect sensitive data, partial encryption through Alibaba Cloud's Key Management Service (KMS) has been sought, thereby boosting security measures. This way is able to ensure the protection of data from poor handling in case of unauthorized access, as shown in Figure 4.

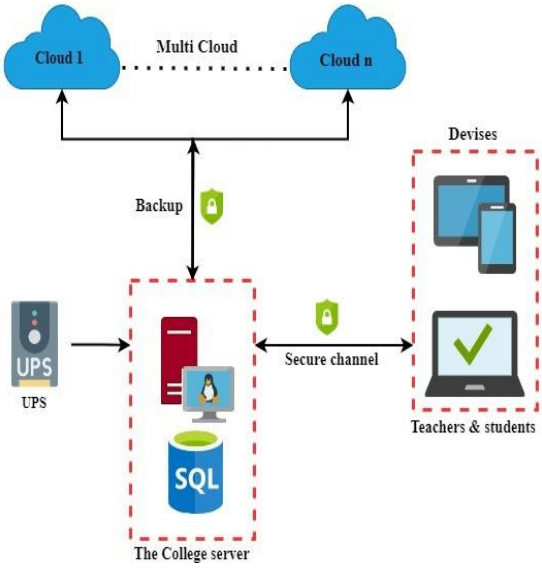

Figure 2: System architecture overview.

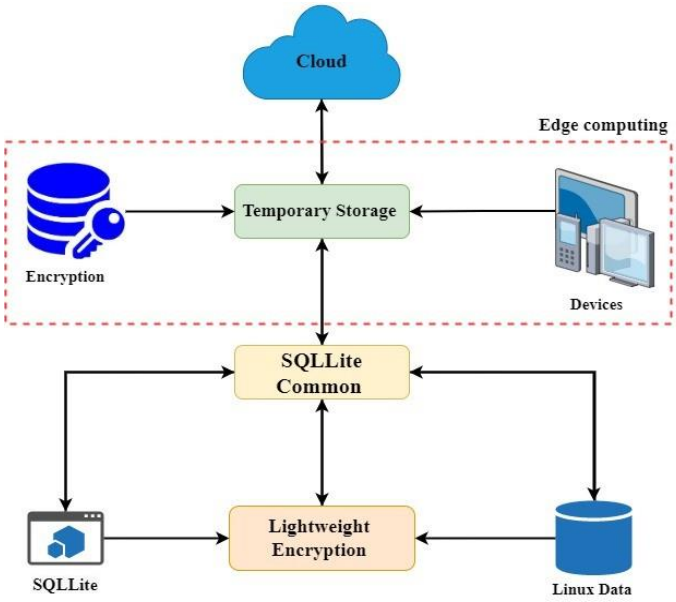

Figure 3: Local server configuration.

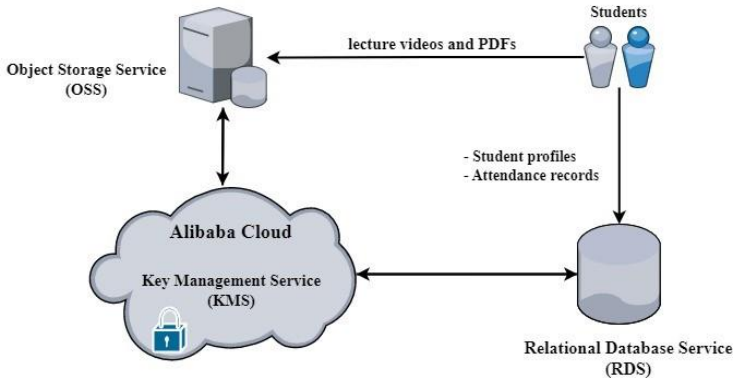

Figure 4: Cloud layer services.

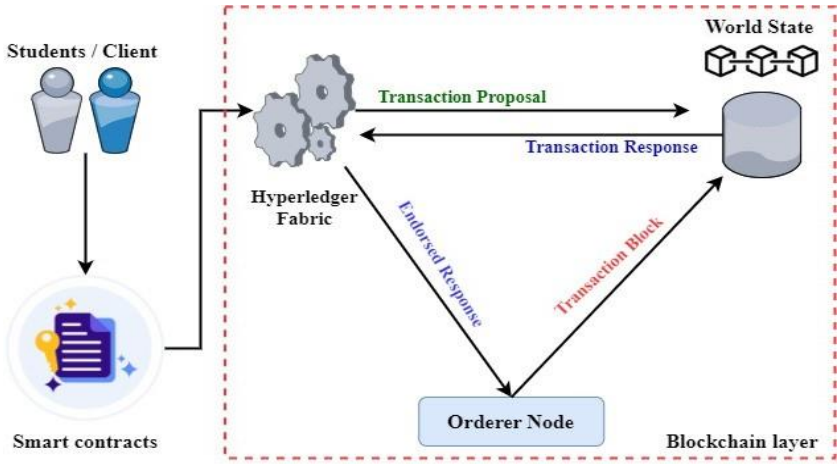

Figure 5: Blockchain network structure.

In the final stage, a blockchain layer was created using Hyperledger Fabric, a permissioned blockchain framework for private network applications. Smart contracts developed in Solidity were utilized to automate the core processes such as grade submissions, certification issuance, and fee payment management. Following this, such smart contracts were deployed in the blockchain network to affix harshly maintained and immutable academic transactions, as indicated in reference [18]. In addition, cryptographic hashing algorithms were integrated to mitigate unauthorized alteration because academic records were subject to change to destroy integrity, as illustrated in Figure 5

5 CONCLUSIONS

Many challenges, especially in Iraq, can be tackled by the novel application of cloud computing to e-learning systems. This project explored the use of cloud technology combined with some elements of blockchain in the cultural environment of the University of Diyala, aiming to solve the problems of inadequate infrastructure, electricity instability, poor technical knowledge, and data security. The proposed framework will implement different cloud computing models such as IaaS, PaaS, and SaaS, giving the university several advantages, including scalability, cost-effectiveness, and better accessibility of its e- learning platform. Cloud storage facilitates central and enhanced access to the learning material from all sources to make it available for users.

Besides, this technology supports real-time interaction in virtual classroom settings, making the features of Learning Management Systems (LMS) to manage courses and monitor the performance of students even more efficient. These features are shielded by a highly strong security mechanism with encryption and multi-factor authentication principles, which are being pioneered to establish a secure and reliable framework for e-learning implementation. Integrating a mathematical model for resource allocation, maintaining a dynamic resource scaling algorithm, accomplishes the combined objective of optimum performance with adaptability to changing system demands. Future work may incorporate the latest technologies, such as blockchain, for unswerving academic record management, and lightweight encryption paths to augment security in a resource-constrained situation. AI also has a complementary role in squeezing more optimization from the system performance. Moving to cloud e-learning, therefore, gives the University of Diyala a loophole through which it can get out of stagnation and offer quality education.

Overall, this contemporary framework increases collaboration among stakeholders, thus giving birth to an inclusive and a scalable ecosystem of education.

ACKNOWLEDGEMENTS

The authors extend their sincere gratitude to the University of Diyala for their invaluable support and collaboration in implementing the proposed e-learning framework. Special thanks to the Computer Science Department at the College of Medicine and the College of Veterinary Medicine, University of Diyala, for providing the necessary infrastructure and resources to facilitate this research.

REFERENCES

[1] F. AlAjmi et al., “Challenges of e-learning in developing countries,” Journal of Educational Technology, vol. 15, no. 3, pp. 45-60, 2021.

[2] A. El Mhouti et al., “Cloud computing in education: Opportunities and challenges,” International Journal of Cloud Applications, vol. 10, no. 2, pp. 112-125, 2021.

[3] M. Hussein and A. Hilmi, “Technical expertise in e-learning adoption,” Educational Research Review, vol. 27, no. 4, pp. 301-315, 2022.

[4] H. Amer and F. Alnaja, “Blockchain for academic records: Transparency and immutability,” Blockchain in Education, vol. 10, no. 2, pp. 112-125, 2023.

[5] R. Shana and A. Abulibdeh, “Lightweight cryptography in IoT devices,” Journal of Cryptography, vol. 15, no. 4, pp. 201-215, 2022.

[6] R. Kumar, “Overcoming infrastructure limitations in e-learning,” Technology in Education, vol. 12, no. 5, pp. 201-215, 2023.

[7] A. Burney and M. Alam, “Power supply issues and their impact on e-learning,” Energy and Education Journal, vol. 10, no. 1, pp. 78-92, 2023.

[8] S. Nazir et al., “Data privacy in cloud-based education systems,” Journal of Information Security, vol. 14, no. 3, pp. 156-170, 2023.

[9] A. Alim et al., “Data privacy in cloud-based education systems,” Journal of Information Security, vol. 14, no. 3, pp. 156-170, 2023, [Online]. Available: https://doi.org/10.4321/jis.2023.140304.

[10] A. Badr, L. C. Fourati, and S. Ayed, “A novel system for confidential medical data storage using chaskey encryption and blockchain technology,” Baghdad Science Journal, vol. 20, no. 6 Suppl, p. 2651, 2023.

[11] A. Saliq et al., “Optimizing cloud resource allocation for e-learning,” Cloud Computing Journal, vol. 18, no. 2, pp. 89-104, 2024.

[12] A. Khanapi and M. Mohamad, "Virtual classrooms using cloud computing," Journal of Online Learning, vol. 15, no. 4, pp. 112-125, 2024.

[13] A. A. Hussein et al., "Survey towards a sustainable information and communication technologies (ICT) in Iraq," in Journal of Physics: Conference Series, vol. 1530, no. 1. IOP Publishing, 2020, p. 012089.

[14] G. K. Ouda and Q. M. Yas, "Design of cloud computing for educational centers using private cloud computing: A case study," J. Phys. Conf. Ser., vol. 1804, no. 1, 2021.

[15] N. Eze et al., "Cultural resistance to e-learning adoption," International Journal of Educational Studies, vol. 12, no. 3, pp. 78-92, 2023.

[16] J. Dignde, et al., "ALCoD: An adaptive load-aware approach to load balancing for containers in IoT edge computing," IEEE Internet of Things Journal, 2024.

[17] I. Mishkhal, N. Abdullah, H. H. Saleh, N. I. R. Ruhaiyem, and F. H. Hassan, "Facial Swap Detection Based on Deep Learning: Comprehensive Analysis and Evaluation," Iraqi Journal for Computer Science and Mathematics, vol. 6, no. 1, Article 8, 2025, [Online]. Available: https://doi.org/10.52866/2788-7421.1229.

[18] R. Alma and L. Piatti, "Smart contract: The contract automation climax. Back-end and front-end legal implications," in Blockchain and Smart-Contract Technologies for Innovative Applications, Springer, 2024, pp. 39-57.