

Blockchain-Based Academic Identity and Transcript Management in University Enterprise Architecture

Djarot Hindarto

Prodi Informatika, Fakultas Teknologi Komunikasi dan Informatika Universitas Nasional, Jakarta
djarot.hindarto@civitas.unas.ac.id

Submitted : Sep 7, 2023 | **Accepted** : Sep 10, 2023 | **Published** : Oct 1, 2023

Abstract: The present research examines the implementation of Blockchain-based Identity and Academic Transcript Management in a university's enterprise architecture. This research is motivated by the increasing demand for secure, transparent, and efficient student identity management and the need to store easily verifiable academic transcripts. Blockchain technology has been spotlighted because it provides security and data integrity solutions. This research aims to determine if integrating Blockchain into the University's Enterprise Architecture can improve the management of student identities and academic transcripts by reducing the risk of forgery and facilitating more dependable access for interested parties. Increased security and efficiency in managing student data are the practical implications of this research, which can help universities reduce the risk of data loss and increase stakeholder trust. This research method includes surveying various universities that have adopted Blockchain technology in their academic identity and transcript management. In addition, we will assess its technical implementation, evaluate its effect on efficiency, and conduct interviews with university personnel involved in the implementation process. This study's anticipated outcome is providing universities planning to adopt Blockchain technology for Enterprise Architecture with actionable guidance. This research will identify the benefits, challenges, and best practices of integrating Blockchain in academic identity and transcript management and lay the groundwork for further improvement of educational services in university settings.

Keywords: Blockchain Technology; Enterprise Architecture; Identity and Academic Transcript Management; University; Security and data integrity solutions

INTRODUCTION

The emergence of Blockchain technology (Goldsby & Hanisch, 2023) initially served as the fundamental framework for cryptocurrencies, notably Bitcoin. Nevertheless, Blockchain technology (Mohd Aman et al., 2021) has progressively extended to diverse industries, encompassing higher education. The technology in question garners interest not solely for its financial implications but also for its capacity to effectively tackle concerns about data security, integrity, and accessibility. In the contemporary era of digital technology, the collection and maintenance of student data have become highly significant for universities, with a paramount emphasis placed on safeguarding its security and long-term viability. In recent decades, universities worldwide have undergone substantial transformations in the administration of student identification and academic transcript management. This phenomenon is observed with the swift progress of information and communication technology,

*name of corresponding author



This is an Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

which has fundamentally altered the higher education environment. Blockchain technology (Ait Hsain et al., 2021) has emerged as a significant development with the potential to address the prevailing challenges in data management in higher education.

Student identity management within the higher education setting has experienced growing complexity. Ensuring secure and managed access has become increasingly pressing due to the growing number of students, staff, and external partners engaging with the university system. Furthermore, the administration of academic transcripts necessitates implementing a system that enables prompt and precise data verification. Educational institutions face the potential hazards of falsifying and manipulating data, which can detrimentally impact the university's reputation and the students implicated therein. In the present scenario, utilizing Blockchain technology within the framework of university enterprise architecture is perceived as a highly promising and viable resolution. This technological advancement facilitates data storage in a secure, distributed, and encrypted manner. In the context of Blockchain technology, it is essential to note that all data inputted into the system is accompanied by a timestamp, rendering it chronologically traceable.

Furthermore, the immutability of this data ensures that it cannot be altered or tampered with once it has been recorded. Additionally, verifying such data by relevant authorities is a straightforward process, enhancing the reliability and trustworthiness of the information stored within the Blockchain. This can improve student identity management, ensure the security of academic transcripts, and facilitate more convenient and dependable access for relevant stakeholders. In light of the context mentioned above, the primary objective of this research is to examine the potential of integrating Blockchain technology into the enterprise architecture of universities. The aim is to address the existing obstacles in student identity management and the administration of academic transcripts. Therefore, this study examines the pragmatic ramifications of using this technology and handles several fundamental inquiries. Furthermore, this study seeks to ascertain the optimal integration of Blockchain technology into current enterprise architectures while minimizing disruptions to existing systems. Additionally, it aims to identify and analyze the primary challenges that may arise during this integration process.

Global higher education institutions have undergone substantial transformations in student identity and academic transcript management. The advent of Blockchain technology (Viano et al., 2023), initially introduced as the fundamental framework for cryptocurrencies like Bitcoin, has presented novel prospects for addressing prevailing data management obstacles in higher education. The security, integrity, and accessibility of student data are of utmost importance in the current digital age. As a potential solution to enhance identity and academic transcript management, integrating Blockchain technology into university enterprise architecture is gaining prominence. Many higher education institutions have encountered persistent challenges in safeguarding the confidentiality and integrity of their student data. The immediate attention and resolution of issues about cyberattacks, data breaches, and the potential for academic transcript falsification are imperative. Prior studies have explored diverse methodologies to enhance the security and integrity of data, such as implementing distributed databases. However, implementing Blockchain technology (Davidson, 2023) offers more sophisticated solutions by leveraging its decentralized and secure characteristics. Incorporating Blockchain technology within the university's enterprise architecture is expected to enhance the administration of student identities and academic transcripts. This integration aims to mitigate the potential risks associated with counterfeiting while facilitating convenient and trustworthy access for relevant stakeholders. Therefore, this analysis of Blockchain offers a more comprehensive comprehension of the tangible consequences related to the utilization of this technology within the realm of higher education.

The current research will investigate whether the application of Blockchain technology to identity and academic transcript management in higher education can enhance data security, streamline the verification process, and increase operational efficiency. This research will also investigate how this technology can be effectively integrated into higher education's enterprise architecture (Prawira et al., 2023), (Hindarto et al., 2021), (Wedha & Hindarto, 2023) without disrupting existing systems. This research will answer several questions regarding technical aspects, data management, and operational efficacy. Through this research, we can provide both an in-depth understanding of the role of Blockchain technology in university enterprise architecture (Hindarto, 2023) and practical guidance for universities planning to adopt this technology. This research will also identify the benefits, difficulties, and best

*name of corresponding author



This is anCreative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

practices of integrating Blockchain technology in academic identity and transcript management, which will positively impact the global development of educational services in higher education institutions.

Several research questions arose from the preliminary description and provided the foundation for implementing Blockchain-based Identity and Academic Transcript Management in University Enterprise Architecture:

- a. How can implementing Blockchain technology in university enterprise architecture enhance the security of student data and academic transcripts and reduce the likelihood of forgery? (First Investigation Question)
- b. How will integrating Blockchain technology into higher education identity and academic transcript management impact data verification, accessibility, and operational efficiency? (Second Investigation Question)
- c. How can Blockchain technology be effectively integrated into the enterprise architecture of a university without disrupting existing systems, and what are the primary obstacles to this integration? (Third Investigation Question)

This research question is expected to elucidate the potential, implications, and challenges of implementing Blockchain technology in the context of identity management and academic transcripts in higher education.

LITERATURE REVIEW

In an era characterized by dynamic transformations resulting from the rapid advancement of information and communication technology, researchers and practitioners alike must comprehensively comprehend the most recent advances within Blockchain. This entails recognizing emerging trends and pivotal concerns and assessing the impact of prior scholarly investigations. This literature review aims to thoroughly understand the intersection between Blockchain and Enterprise Architecture by examining relevant literary sources. This study aims to comprehensively analyze essential concepts, theories, significant findings, and areas of limited understanding. This analysis will serve as a valuable framework for directing our research in a more informed and effective manner.

Blockchain technology for enterprise credit information sharing in supply chain finance (Zheng et al., 2022). The implementation of blockchain technology has the potential to effectively mitigate credit data barriers within the supply chain financial credit system. The proposed model incorporates consensus mechanisms to ensure data integrity and safeguard privacy, thereby enabling the implementation of supply chain finance applications. This implementation enhances the efficiency of the credit investigation service system and contributes to the improvement of supply chain financing efficiency. Blockchain for healthcare systems: Architecture, security challenges, trends and future directions (J et al., 2023). Blockchain technology is a disruptive innovation that can potentially revolutionize multiple sectors, including the healthcare industry. This article examines the importance of healthcare, its features, use cases, interoperability, and security challenges. It also offers insights into ongoing research and potential prospects. Dynamic Enterprise Architecture planning using case-based reasoning and blockchain (Ettahiri & Doumi, 2022). This work highlights the significance of Enterprise Architecture in preparing for uncertain future changes. It recommends using Case-Based Reasoning (CBR) to store and adapt problem solutions, enhancing the knowledge base for sound decision-making. In addition, it proposes blockchain-based knowledge sharing among affiliated businesses for regional implementation of national strategies. A novel blockchain-based architectural modal for healthcare data integrity: Covid19 screening laboratory use-case (BARBARIA et al., 2023). This paper proposes a blockchain-based model for ensuring the integrity of healthcare data in AI-based medical research. It employs the HL7 FHIR standardization for interoperability with hospital information systems, thereby improving data quality and security. Combining Continua Healthcare IoT and Hyperledger Fabric architecture, the model includes components for data exchange, blockchain access control, privacy protection, and API accessibility to increase confidence in medical research procedures. Security challenges and defense approaches for blockchain-based services from a full-stack architecture perspective (H. Chen et al., 2023). This research addresses security challenges in blockchain technology,

*name of corresponding author



This is anCreative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

offering a comprehensive full-stack architecture perspective. It provides formal definitions of security architecture and outlines security issues and solutions. Smart contract formal verification experiments and real attack event reproductions are conducted. The study uses Alibaba's blockchain services and Hyperledger Fabric's Identity Mixer for analysis, paving the way for future research directions.

Several research gaps or areas that need to be adequately covered can be identified based on the above research summary. Integration of Blockchain with Enterprise Architecture needs a conceptual and practical explanation of how Blockchain is implemented. By addressing this deficiency, this research can provide more comprehensive and valuable insights into the use of Blockchain in various industrial contexts and assist in overcoming the challenges and difficulties that may arise from adopting this technology.

METHOD

Enterprise Architecture

Enterprise Architecture (EA) (Hindarto, 2023) is a discipline that employs the TOGAF Architecture Development Method (ADM) Framework to encompass the entirety of the life cycle associated with enterprise architecture development. The following sections are presented:

The preliminary phase marks the initiation of the TOGAF Architecture Development Method (ADM) life cycle. The objective is to commence and structure an enterprise architecture initiative, encompassing the comprehension of the organizational context, business objectives, and accessible resources. At this juncture, the primary actors involved are also delineated, and a preliminary comprehension of the external and internal factors that impact the architecture is established.

Phase A: Development of Architectural Vision: The primary objective of this phase is to establish a comprehensive architectural vision that will serve as a guiding framework for subsequent development activities. This necessitates a more profound comprehension of the business objectives, prospects, and obstacles that enterprise architecture must confront. The outcome is an Architectural Vision document that establishes architecture's perspective and fundamental tenets.

Phase B, Business Architecture, is centered around modeling and comprehending business processes and organizational structures. This encompasses the activities of business process mapping, business modeling, and the identification of business needs.

Phase C of the project involves examining and developing the information systems architecture. Currently, the primary emphasis is placed on modeling data and information systems that facilitate business processes. This encompasses application planning, data modeling, and establishing connections between business processes and the corresponding information systems that enable their operations.

Phase D, known as the Technology Architecture phase, is dedicated to analyzing and evaluating the technological infrastructure required to support applications and data within an organization effectively. This encompasses choosing appropriate technologies, creating infrastructure models, and determining suitable technical solutions.

Phase E focuses on identifying opportunities and proposing solutions. This phase aims to analyze the current situation and determine potential areas for improvement. Examining the existing challenges and constraints aims to generate innovative ideas and develop effective strategies to address them. During this phase, the evaluation and planning of innovation opportunities and solutions that can contribute to attaining architectural objectives are conducted. The process encompasses the examination of potential alterations in the business and technology landscape alongside identifying prospects for enhancement and innovation.

Phase F, known as Migration Planning, encompasses the strategic planning and execution of the architecture that has been previously developed. This includes identifying and evaluating migration initiatives, organizing the implementation timeline, and formulating a comprehensive migration strategy.

In addition, the TOGAF Architecture Development Method (ADM) encompasses supplementary stages, namely Phase G (Implementation Governance), Phase H (Architecture Change Management), and Phase Requirements Management (Requirements Management). These stages play a crucial role in the effective management and maintenance of the architecture following its implementation.

*name of corresponding author



This is an Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Organizations can effectively develop, implement, and manage their enterprise architecture by systematically progressing through several stages. This structured sequence enables alignment with business objectives and facilitates adaptability to evolving business and technological landscapes. In this section, each researcher is expected to be able to make the most recent contribution related to the solution to the existing problems. Researchers can also use images, diagrams, and flowcharts to explain the solutions to these problems. Implementing TOGAF ADM (The Open Group Architecture Development Method) within a university setting can yield several strategic advantages in information architecture and technology infrastructure management.

Blockchain Technology

Blockchain technology (Hiwale et al., 2023), (Waqar et al., 2023) has emerged as a groundbreaking innovation that has revolutionized our comprehension and administration of data, particularly within digital transactions and safeguarding information integrity. Initially, it surfaced as the fundamental framework for the inaugural digital currency, Bitcoin. However, it has undergone development and transformation, becoming a versatile technology with extensive utility in diverse sectors. Decentralization stands out as a prominent attribute within the realm of blockchain technology. This system's functionality does not rely on a sole central authority or a solitary server.

In contrast, data storage occurs across a distributed network of computers called "nodes." Every individual node possesses a comprehensive replica of the blockchain ledger, encompassing a complete record of all transactions executed within the network. When a novel transaction takes place, it is appended to a block, which is subsequently linked to preceding blocks, thereby constituting a blockchain. The rationale behind using the term "blockchain" is as follows. Each block within the blockchain comprises a specific quantity of transactions, and each block is intricately linked to the preceding block, thereby establishing an immutable chain. This feature offers a robust level of protection against the manipulation or modification of data within the system.

Furthermore, the utilization of blockchain involves the implementation of robust cryptographic methodologies to ensure the security of data. Every transaction undergoes encryption and is subsequently appended to the blockchain alongside a distinct digital signature. This mechanism guarantees that only authorized entities can verify transactions, and any alteration to the data necessitates modifying the entire blockchain. The enhanced level of security offered by blockchain technology has rendered it highly appealing to numerous industries, particularly those about finance, identity, and privacy. Transparency is a significant attribute within the context of blockchain technology. While the ledger containing all data is made available to every node in the network, the disclosure of individual identities in transactions is only sometimes guaranteed. In the context of the Bitcoin network, it is worth noting that transactions are exclusively associated with anonymous digital wallet addresses. This configuration ensures the necessary degree of confidentiality while also facilitating extensive visibility within the ledger.

To verify and add transactions to the ledger, blockchain necessitates consensus among nodes within the network. Establishing this consensus guarantees that a transaction is deemed valid only when there is unanimous agreement among all nodes regarding its legitimacy. Proof of Work (PoW) is a frequently employed consensus algorithm that incorporates the process of cryptographic mining. Nevertheless, alternative approaches, such as Proof of Stake (PoS), exhibit a higher degree of environmental sustainability. The potential applications of blockchain technology are extensive. In addition to cryptocurrencies, this technology has been implemented in diverse domains, encompassing intelligent contracts, supply chain management, digital identity, electronic voting, and even the financial sector, to diminish transaction expenses and enhance security measures.

However, blockchain technology encounters various challenges and obstacles similar to any other technological advancement. Initially, blockchain technology has the potential to offer a significant degree of security. However, it is essential to acknowledge that blockchain operation, particularly within cryptocurrency networks, necessitates substantial computational resources. Furthermore, it is imperative to recognize the scalability concern, as certain blockchains may encounter difficulties in effectively handling significant transaction volumes. Finally, it is essential to note that blockchain's legal and

regulatory aspects are currently in a state of development, necessitating a more comprehensive understanding of the legal structure governing this innovative technology.

In summary, blockchain technology possesses significant potential to revolutionize our interactions with data and digital transactions. The technology provides

- a. a robust level of security,
- b. a high degree of transparency and
- c. the capacity to disrupt various sectors.

To fully harness the potential of this technology, it is imperative to address multiple technical, economic, and regulatory obstacles. Through ongoing advancements, blockchain technology has the potential to persist as a catalyst for innovation across diverse sectors of the economy.

Academic Identity and Transcript Management

The management of academic identity and transcript plays a crucial role in the administration of higher education, exerting significant influence on students, colleges, and educational institutions. Academic Identity Management pertains to the administration of student identity data and information, encompassing personal details, educational background, and necessary qualifications. This includes the tasks of documenting student admissions, allocating student identification numbers, and overseeing student privileges for accessing various systems and services. Efficient management of academic identity facilitates the monitoring of educational advancement and provides students with seamless access to university resources.

Conversely, an Academic Transcript is an authoritative documentation of a student's scholastic accomplishments, encompassing a comprehensive enumeration of courses undertaken, corresponding grades attained, and additional notable attainments. The provided transcript serves as a means of verifying one's degree and as a valuable resource for students pursuing further education or seeking employment opportunities. Efficient management of academic transcripts encompasses the meticulous recording and storage of transcripts, ensuring a high degree of precision while facilitating convenient and secure access to this data for students and educational institutions.

Utilizing blockchain technology has emerged as a promising solution for enhancing the management of Academic Identity and Transcript. Blockchain technology (Z. Chen, 2023) enables the secure and transparent recording of student identities and academic track records. The data mentioned above has the potential to undergo encryption and subsequent storage within an immutable blockchain, thereby mitigating security vulnerabilities and obviating concerns related to counterfeiting. Moreover, the implementation of blockchain technology empowers students with enhanced autonomy over their personal information, enabling them to grant permission to external entities, including prospective employers or educational institutions, to validate academic qualifications.

Integrating blockchain technology in managing Academic Identity and Transcript can yield several benefits for educational institutions. These advantages include enhanced administrative efficiency, heightened security measures for student data, and improved tools for students to manage and leverage their credentials effectively. This can also reduce administrative costs and the time needed to authenticate academic information, yielding long-term advantages for the entire higher education ecosystem. Therefore, the integration of blockchain technology in Academic Identity and Transcript Management has the potential to play a crucial role in fostering positive transformations within the realm of higher education.

Design

ArchiMate is a specialized modeling language for enterprise architecture that has been purposefully developed to facilitate the planning, analysis, and communication of an organization's enterprise architecture. The framework offers a robust structure for delineating fundamental components within architecture, including but not limited to business processes, applications, technology infrastructure, and various other elements. The primary benefit of ArchiMate lies in its capacity to integrate an organization's business, technical, and IT dimensions within a unified and organized framework. The modeling process in ArchiMate involves utilizing diverse elements and relationships. The elements encompass a range of components, such as actors, objects, roles, functions, and other entities that

*name of corresponding author



This is an Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

represent various facets of the architecture. The interconnections among these elements are employed to illustrate how they interact within the framework of an enterprise architecture. One can use the ArchiMate framework to depict the interdependencies between specific business processes and the applications and technological infrastructure they rely upon.

One additional benefit of ArchiMate is its capacity to facilitate architectural modeling across multiple layers of abstraction, spanning from the conceptual to the intricately detailed technical level. This enables the interaction between enterprise architects and diverse organizational stakeholders, encompassing executive-level management, IT developers, and business stakeholders. Furthermore, ArchiMate exhibits compatibility with various architectural frameworks, including TOGAF (Gonçalves et al., 2021) (The Open Group Architecture Framework), facilitating the implementation of a holistic enterprise architecture methodology within organizations. ArchiMate is a robust and versatile architectural modeling language that facilitates enterprise architecture development, administration, and dissemination within organizations. ArchiMate enables the precise and comprehensive representation of diverse architectural dimensions, ranging from business to technical, by providing a diverse range of structured components and interconnections. The utilization of this tool proves to be highly advantageous for enterprise architects as it effectively facilitates the preservation of coherence and accessibility within their enterprise architecture.

Implementation

The utilization of ArchiMate design in the implementation of research constitutes a crucial undertaking in applying enterprise architecture principles within this research endeavor. The ArchiMate language is a tool for architectural modeling, facilitating the design and effective communication of diverse elements within enterprise architecture.

RESULT

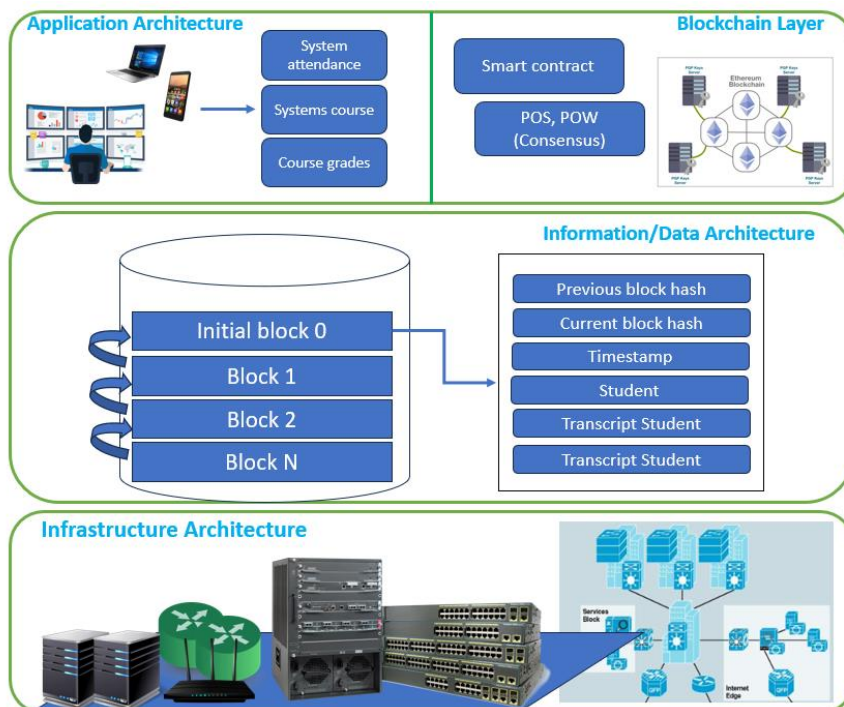


Fig. 1 Enterprise Architecture & Blockchain Layer

Source: Researcher Property

Fig. 1, Application architecture, Information architecture, Infrastructure architecture, and Blockchain Layer are essential components for designing and managing complex IT systems. Each has its role and responsibility in supporting the operation and growth of information technology. Application

*name of corresponding author



architecture initially refers to the design and structure of the system's software applications. This entails choosing a technology, configuring application interactions, and organizing the various functions and modules. Application architecture specifies how applications interact and communicate with users and other infrastructure components. Second, information architecture is associated with managing and organizing system data. This includes database design, storage structures, data format definitions, and application data access and usage. Information architecture is the foundation for systems to provide applications and users with efficient, secure, and accurate data access. Thirdly, Infrastructure architecture pertains to the physical hardware and infrastructure that supports system operations. This includes the design of the network, server, and storage, as well as the selection of the required software and hardware to run applications and store data. Infrastructure architecture must guarantee the accessibility, scalability, and safety of the infrastructure that supports applications and data. The Blockchain Layer is a specific technology layer used in blockchain-based systems. Blockchain is a decentralized digital ledger that employs cryptography to ensure the integrity and security of data. This layer governs how blockchain transactions are recorded, validated, and authorized and grants users access to blockchain features such as smart contracts.

Together with the relevant blockchain layers, these three components create an effective, secure, and well-organized information technology system. When deployed, the Blockchain Layer offers additional security and transparency. This entire architecture is essential for developing successful information technology solutions that can meet the needs of businesses and organizations in the current digital era.

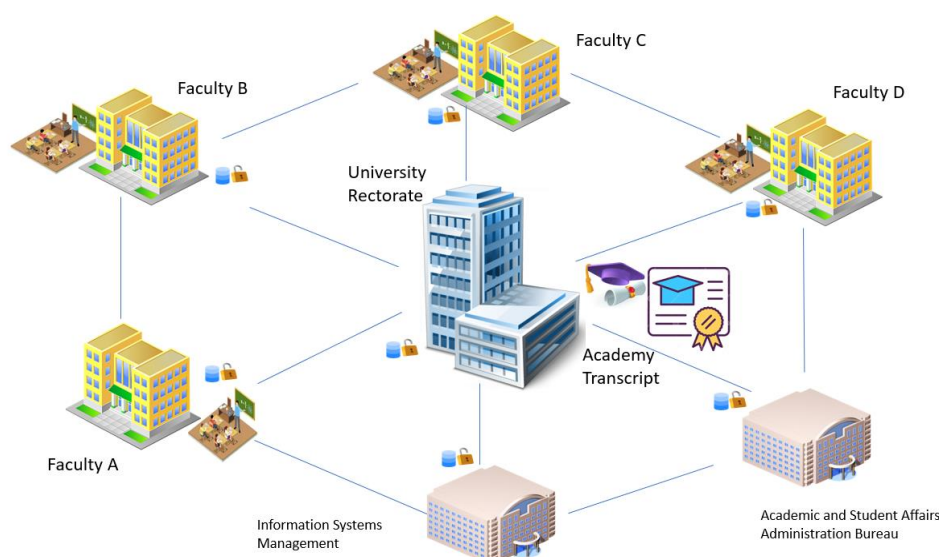


Fig. 2 Enterprise Architecture & Blockchain technology for student transcript systems
Source: Researcher property

Fig. 2, Implementing "Enterprise Architecture & Blockchain Technology for Student Transcript Systems" is a revolutionary step in managing student transcript systems in higher education institutions. Beginning the process is a comprehensive analysis of existing system requirements. This includes a thorough understanding of the current storage, management, and exchange of student transcript data between institutions, students, and third parties requiring verification. The following crucial step is enterprise architecture planning. During this phase, the student transcript system is designed to be integrated with the existing IT infrastructure, ensuring that technology, business processes, and organizational policies are in sync. Identifying users and granting appropriate access permissions is essential so that only authorized parties can access transcript data.

Blockchain technology significantly impacts the security and integrity of transcript data. Using blockchain technology, transcript data becomes immutable, unalterable, and easily verifiable. Each participant, including educational institutions and students, can have nodes in the blockchain network to ensure security and dependability. Integration with external systems is also crucial for facilitating

*name of corresponding author



This is anCreative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

secure and efficient data exchange. In this implementation, system maintenance and management are essential in ensuring optimal performance, security updates, and continuous enhancements in line with technological advancements.

Furthermore, user education is essential to the success of these systems. Students and faculty must receive training on how to use this system correctly so they can access and verify their transcripts using blockchain technology. By implementing "Enterprise Architecture & Blockchain Technology for Student Transcript Systems," higher education institutions can improve the transparency, security, and integrity of student transcript data management and reduce the likelihood of fraud and forgery. This is a crucial step towards a more efficient and trustworthy future in education.

Sequence diagrams are a useful visual tool for using blockchain technology to improve student transcript systems in higher education institutions. The sequence diagram can illustrate how the student transcript verification process via blockchain occurs, from the student's request to the educational institution's validation, painting a clear picture of how this technology can alter the way transcript data is managed in academic environments. In Figure 3, the explanation needs to be more detailed, but it is sufficient to describe the process of integrating blockchain with the proposed transcript system.

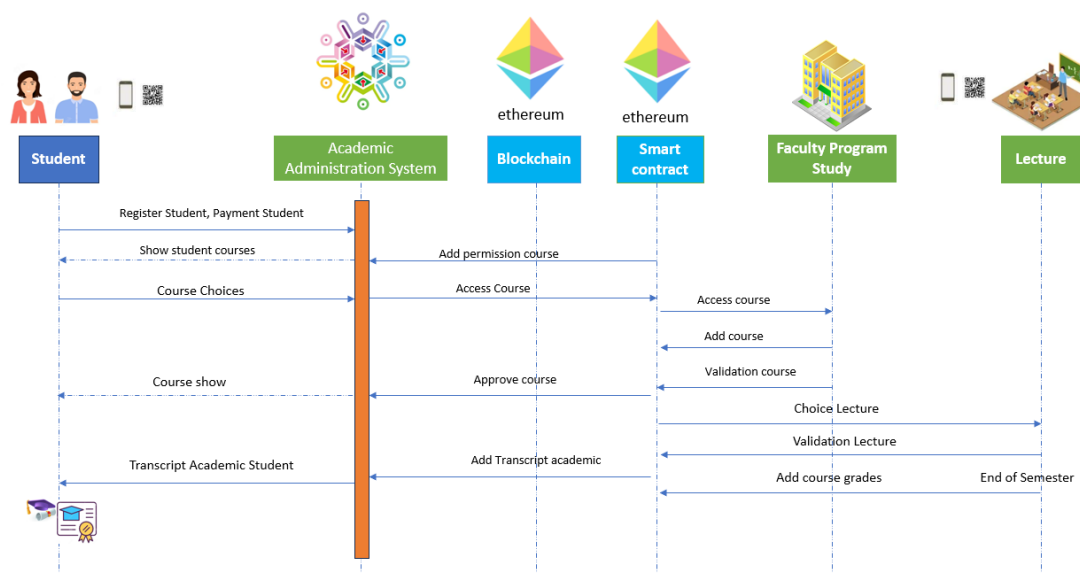


Fig. 3 Sequence Diagram
Source: Researcher Property

The procedure starts when a student enrolls in college. At this point, they provide the system with their personal and academic information. The sequence diagram will demonstrate that the registration request will initiate messages to various system components, including the financial system, to initiate tuition payments. After the student has made a payment, the system will send the student a payment confirmation. In addition, the subsequent step in the sequence diagram will illustrate how intelligent contracts on the blockchain are utilized to validate payments. Smart contracts are pre-programmed digital agreements to carry out specific actions when certain conditions are met. In this instance, the smart contract will validate that payment has been received and grant students' access to the system to complete their one-semester course schedule.

Students can now access the system and select the courses they wish to take. After they have completed filling out the course plan, the system will store this information and grant access to lecturers from the appropriate faculties. The sequence diagram will illustrate how professors gain access to student course plans, prepare instructional materials, and deliver lectures. During the study, the instructor evaluates the students. This procedure will also be reflected in a sequence diagram by sending assessment information to the academic and administrative systems. After all courses have been completed and assessments have been administered, the system will calculate the student's average grade

*name of corresponding author



and determine whether or not the course has been completed. Finally, if students have completed all courses successfully, the sequence diagram will illustrate how the system generates academic transcripts for students. This transcript will list all completed courses, earned grades, and other educational information. All students who graduate will receive this transcript as evidence of their accomplishments.

This process can be better understood with sequence diagrams, which clearly show how blockchain technology and information systems interact in higher education to manage enrollment, payment, teaching, grading, and transcript awarding.

DISCUSSIONS

How can implementing Blockchain technology in university enterprise architecture enhance the security of student data and academic transcripts and reduce the likelihood of forgery? (First Investigation Question).

Implementing Blockchain technology in university enterprise architecture can increase the security of student data and academic transcripts while decreasing the likelihood of forgery. Student data and academic transcripts can be encrypted and stored in blocks across the network using strong cryptography and a distributed network, making them difficult to manipulate or access by unauthorized parties. The time signature and immutability inherent to Blockchain ensure that any changes or additions to data are transparently recorded and cannot be altered without network consensus, thereby eliminating the possibility of data falsification. Moreover, Blockchain enables transparency and public verification, allowing anyone to independently and transparently verify data without relying on a central authority. Students have complete control over their data and can grant access permissions to authorized parties, but their data remains secure. In addition, Blockchain's distributed nature makes it resistant to attacks and provides additional operational efficiency benefits. Thus, using Blockchain technology in university enterprise architecture is crucial to establishing a more secure, trusted, and efficient ecosystem for managing student identities and academic transcripts. This will have long-term benefits for developing academic reputation and improving security and confidence in higher education.

How will integrating Blockchain technology into higher education identity and academic transcript management impact data verification, accessibility, and operational efficiency? (Second Investigation Question)

The incorporation of Blockchain technology in higher education, specifically in the management of academic transcripts and identities, is anticipated to yield noteworthy benefits in data verification, accessibility, and operational efficiency. Firstly, in data verification, Blockchain offers high certainty and transparency. The utilization of Blockchain technology for storing student identity data and academic transcripts offers distinct advantages, primarily due to the presence of a transparent time signature and the immutability of the stored information. Consequently, the verification process of such data is enhanced, leading to increased efficiency and reliability. Authorities can efficiently verify a student's educational history without engaging a third party or relying on manual confirmation. Furthermore, regarding accessibility, Blockchain technology eliminates the obstacles and administrative red tape commonly associated with retrieving academic information. Authorized parties can access data stored in the Blockchain, regardless of geographical location, provided they possess the necessary permissions. Students are allowed to conveniently retrieve their academic transcripts via an interface that is designed to be user-friendly. Furthermore, implementing Blockchain technology can benefit operational efficiency by diminishing administrative expenses and enhancing the efficacy of academic identity and transcript management. The automation of data storage, retrieval, and verification processes has the potential to minimize the reliance on labor-intensive manual tasks. This has the potential to assist universities in optimizing the allocation of their resources towards essential educational pursuits. Incorporating Blockchain technology in managing identity and academic transcripts in higher education not only enhances the security and reliability of data but also offers notable operational efficiencies for universities. Implementing this system is expected to yield advantages for students, as it will streamline the process of accessing their data. Additionally, universities stand to gain long-term benefits from this initiative, which is anticipated to reduce administrative expenses and enhance confidence in the higher education sector.

*name of corresponding author



This is anCreative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

How can Blockchain technology be effectively integrated into the enterprise architecture of a university without disrupting existing systems, and what are the primary obstacles to this integration? (Third Investigation Question).

The effective integration of Blockchain technology into a university's enterprise architecture can be achieved by carefully considering several essential steps. Introducing Blockchain technology necessitates a comprehensive comprehension of the objectives and requirements that must be fulfilled. This enables higher education institutions to develop suitable strategies for integration. In addition to the considerations above, selecting an appropriate Blockchain platform or system is essential. Open-source platforms like Ethereum or Hyperledger Fabric are frequently employed within higher education. Subsequently, a thorough analysis of the data intended for migration into the Blockchain is imperative, alongside the requisite adaptation of the data format to align with the structure of the Blockchain. This process may entail modifications to the design of the data or the implementation of essential data conversions. Furthermore, universities can benefit from collaborating with external entities with specialized knowledge in Blockchain technology, facilitating integration. Third-party entities can offer customized solutions that align with the specific requirements of the university. Regulatory and security aspects hold significant importance when integrating Blockchain technology. Implementing Blockchain technology within higher education may necessitate adherence to specific regulatory frameworks. Therefore, universities must prioritize compliance with relevant guidelines and regulations to ensure proper utilization of this technology.

Nevertheless, the integration of Blockchain faces various challenges that must be addressed. One of the primary challenges lies in the considerable upfront expenses associated with initial implementation, encompassing costs related to development, staff training, and testing. Moreover, the process of acclimating both staff and students to novel technologies can present a significant hurdle. Ensuring comprehensive comprehension and fostering a sense of ease in utilizing Blockchain technology necessitates considerable time and exertion from all stakeholders. Furthermore, it is imperative to take into account the challenges related to scalability. Blockchain technology is presently confronted with challenges about scalability, specifically in relation to its throughput, which refers to the number of transactions processed per second and its storage capacity. Integrating substantial data in Blockchain poses a significant challenge that requires attention in university settings. In summary, the incorporation of Blockchain technology within the enterprise architecture of a university necessitates meticulous strategic preparation, comprehensive comprehension of prerequisites, and efficient cooperation. Although higher education institutions may face specific challenges, such as upfront expenses and the need for cultural adaptation, the enduring advantages of data protection and operational effectiveness can significantly enhance their overall value.

CONCLUSION

Incorporating Enterprise Architecture within the context of "Blockchain-Based Academic Identity and Transcript Management in University Enterprise Architecture" represents a forward-thinking initiative that presents a prospective resolution to overseeing student academic identity and transcripts within a university setting. In summary, integrating blockchain technology into educational systems offers several significant advantages. These include enhanced security measures for safeguarding student data, achieved through utilizing blockchain's secure and transparent data storage capabilities. Additionally, the integration helps mitigate the potential risks associated with falsifying or manipulating academic information. Furthermore, this methodology has the potential to enhance the accessibility of student information, enabling students to manage and distribute their educational achievements to authorized entities effortlessly. Moreover, the integration of these systems holds the potential to enhance the operational efficiency of the university through the automation of various administrative procedures, including the issuance of transcripts and management of identities. Nevertheless, to attain complete success, it is imperative to approach the obstacles posed by rigorous privacy regulations with caution, guaranteeing that systems maintain compliance with relevant data regulations and safeguard students' privacy. Moreover, implementing blockchain technology necessitates substantial investments in infrastructure and human resource development to ensure efficient management. In summary, incorporating Enterprise Architecture in conjunction with blockchain technology presents significant

*name of corresponding author



This is anCreative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

prospects for enhancing the administration of academic identities and transcripts within university settings. This integration offers the potential to optimize efficiency, bolster security measures, improve data accessibility, and ultimately enhance the overall experience for students.

REFERENCES

- Ait Hsain, Y., Laaz, N., & Mbarki, S. (2021). Ethereum's smart contracts construction and development using model driven engineering technologies: A review. *Procedia Computer Science*, 184, 785–790. <https://doi.org/10.1016/j.procs.2021.03.097>
- BARBARIA, S., MAHJOUBI, H., & RAHMOUNI, H. B. (2023). A novel blockchain-based architectural modal for healthcare data integrity: Covid19 screening laboratory use-case. *Procedia Computer Science*, 219(2022), 1436–1443. <https://doi.org/10.1016/j.procs.2023.01.433>
- Chen, H., Luo, X., Shi, L., Cao, Y., & Zhang, Y. (2023). Security challenges and defense approaches for blockchain-based services from a full-stack architecture perspective. *Blockchain: Research and Applications*, 4(3), 100135. <https://doi.org/10.1016/j.bcra.2023.100135>
- Chen, Z. (2023). Innovation and Green Development Enhancing the engineering supervision process in China: A solution enabled by integrating hybrid blockchain system. *Innovation and Green Development*, 2(4), 100091. <https://doi.org/10.1016/j.igd.2023.100091>
- Davidson, S. (2023). Journal of Economic Behavior and Organization Blockchain and the information – calculation problem. *Journal of Economic Behavior and Organization*, 213(July), 142–150. <https://doi.org/10.1016/j.jebo.2023.07.007>
- Ettahiri, I., & Doumi, K. (2022). Dynamic Enterprise Architecture planning using case-based reasoning and blockchain. *Procedia Computer Science*, 204, 714–721. <https://doi.org/10.1016/j.procs.2022.08.086>
- Goldsby, C. M., & Hanisch, M. (2023). Agency in the algorithmic age: The mechanisms and structures of blockchain-based organizing. *Journal of Business Research*, 168(August), 114195. <https://doi.org/10.1016/j.jbusres.2023.114195>
- Gonçalves, D., Ferreira, L., & Campos, N. (2021). Enterprise architecture for high flexible and agile company in automotive industry. *Procedia Computer Science*, 181(2019), 1077–1082. <https://doi.org/10.1016/j.procs.2021.01.303>
- Hindarto, D. (2023). Application Of Customer Service Enterprise Architecture In The Transportation Industry. *Journal of Computer Networks , Architecture and High Performance Computing*, 5(2), 682–692.
- Hindarto, D., Indrajit, R. E., & Dazki, E. (2021). Sustainability of Implementing Enterprise Architecture in the Solar Power Generation Manufacturing Industry. *Sinkron*, 6(1), 13–24. <https://jurnal.polgan.ac.id/index.php/sinkron/article/view/11115>
- Hiwale, M., Walambe, R., Potdar, V., & Kotecha, K. (2023). A systematic review of privacy-preserving methods deployed with blockchain and federated learning for the telemedicine. *Healthcare Analytics*, 3(April), 100192. <https://doi.org/10.1016/j.health.2023.100192>
- J, A., Isravel, D. P., Sagayam, K. M., Bhushan, B., Sei, Y., & Eunice, J. (2023). Blockchain for healthcare systems: Architecture, security challenges, trends and future directions. *Journal of Network and Computer Applications*, 215(September 2022), 103633. <https://doi.org/10.1016/j.jnca.2023.103633>
- Mohd Aman, A. H., Hassan, W. H., Sameen, S., Attarbashi, Z. S., Alizadeh, M., & Latiff, L. A. (2021). IoMT amid COVID-19 pandemic: Application, architecture, technology, and security. *Journal of Network and Computer Applications*, 174(November), 102886. <https://doi.org/10.1016/j.jnca.2020.102886>
- Prawira, K. T., Hindarto, D., & Indrajit, E. (2023). *Application of Enterprise Architecture in Digital Transformation of Insurance Companies*. 8(2), 856–865.
- Viano, C., Avanzo, S., Boella, G., Schifanella, C., & Giorgino, V. (2023). Civic Blockchain: Making blockchains accessible for social collaborative economies. *Journal of Responsible Technology*, 15(August), 100066. <https://doi.org/10.1016/j.jrt.2023.100066>
- Waqar, A., Hannan Qureshi, A., Othman, I., Saad, N., & Azab, M. (2023). Exploration of challenges to

*name of corresponding author



This is anCreative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

- deployment of blockchain in small construction projects. *Ain Shams Engineering Journal*, xxx, 102362. <https://doi.org/10.1016/j.asej.2023.102362>
- Wedha, B. Y., & Hindarto, D. (2023). *Maximizing ERP Benefits with Enterprise Architecture : A Holistic Approach*. 5(2), 703–713.
- Zheng, K., Zheng, L. J., Gauthier, J., Zhou, L., Xu, Y., Behl, A., & Zhang, J. Z. (2022). Blockchain technology for enterprise credit information sharing in supply chain finance. *Journal of Innovation and Knowledge*, 7(4), 100256. <https://doi.org/10.1016/j.jik.2022.100256>

*name of corresponding author



This is anCreative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.