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Blockchain-Based Academic Information System to Enhance Data Security

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ABSTRACT

In the rapidly evolving digital era, educational institutions face significant challenges in managing and securing academic data. Academic data, which includes sensitive information such as student records, faculty details, grades, and attendance, is vulnerable to risks like theft, fraud, and information leakage. This research aims to develop and implement a blockchain-based academic information system to enhance data security and transparency in educational institutions. The research method used is Rapid Application Development (RAD), which allows for quick software development through rapid iterations and active user involvement. The research stages include requirements planning, system design, construction, and implementation and testing. The developed system is designed to store academic data on an encrypted blockchain ledger, with each data change recorded as a new, immutable transaction. The research results show that the implementation of blockchain technology is effective in maintaining the integrity and security of academic data. The system can prevent data manipulation through cryptographic mechanisms, hashing, and consensus. Additionally, transparency in academic data management is increased, allowing all authorized parties to verify data in real-time without third-party involvement. System testing shows a significant improvement in academic data security compared to traditional centralized systems. The evaluation of transparency and user satisfaction levels also indicates that this system provides a positive experience and meets user needs in various aspects. Overall, this research confirms that blockchain technology can be an innovative solution to address the challenges of academic data security and transparency in educational institutions, providing significant benefits to all stakeholders.

Keywords: Blockchain, Data Security, Transparency, Academic Information System, Rapid Application Development.

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INTRODUCTION

In the rapidly evolving digital era, educational institutions face significant challenges in managing and securing academic data. Academic data includes sensitive information such as student records, faculty details, grades, and attendance. Data security is crucial to prevent theft, fraud, and information leakage that can harm institutions. Traditional methods of managing data are often ineffective in addressing increasingly complex security threats. Academic information systems based on conventional databases are vulnerable to hacking, data manipulation, and unauthorized access. Although encryption technology and access control can help, they do not always provide full assurance of data security.

In recent years, educational institutions worldwide have increasingly become targets of data breaches, with rising cases of data theft and leakage of personal information of students and faculty. This highlights the urgent need for stronger and more reliable security systems. There is a growing demand

for transparency in academic data management, with stakeholders such as students, parents, and regulators seeking assurance that data is managed securely and cannot be manipulated.

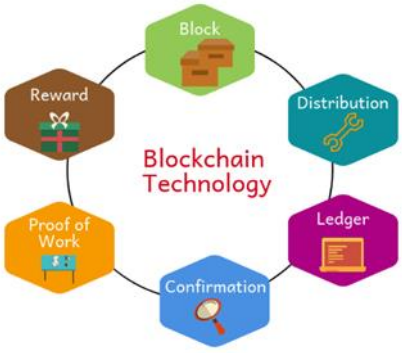

Figure 1. Blockchain Technology

Blockchain, with its transparent and immutable nature, offers a solution to meet the needs for data security and transparency. Blockchain technology has been accepted in various industries as a solution to data security and integrity issues. From the financial sector to healthcare, blockchain has proven effective. Therefore, educational institutions should be encouraged to adopt blockchain technology to protect their academic data[1].

Traditional academic information systems often rely on centralized databases, which are vulnerable to hacker attacks. Blockchain offers a distributed approach that can overcome these limitations, providing an immutable audit trail. Additionally, with the increasing demand for data validation and verification, educational institutions need reliable techniques to ensure the authenticity and integrity of academic data. Blockchain can effectively meet these needs[2].

Educational institutions should be encouraged to adopt new technologies to improve efficiency and effectiveness. The use of blockchain in academic information systems reflects the trend of technological innovation in the education sector, aiming to improve administrative processes and data management. With increasingly stringent personal data protection regulations, educational institutions are expected to comply with higher security standards. Blockchain can help institutions meet regulatory requirements by providing a secure and transparent system for managing academic data[3].

Blockchain technology is known for its ability to maintain data integrity and security. Blockchain provides a distributed and transparent recording system, where each transaction or data change is recorded in cryptographically linked blocks. This can create an immutable audit trail and minimize the risk of manipulation and unauthorized access. The design of a Blockchain-Based Academic Information System aims to enhance data security, transparency, and accountability, as well as minimize the potential for fraud and misuse of information. Thus, educational institutions can manage academic data in a safer, more efficient, effective, and reliable manner. Research and development of blockchain-based academic information systems are essential steps in improving data security and integrity in educational institutions.

LITERATURE REVIEW

Blockchain is known as a technology that provides security and transparency through a distributed and cryptographic recording system. Nakamoto (2008), in his white paper introducing Bitcoin, explains that blockchain allows each transaction to be recorded in chronologically linked blocks, creating an immutable audit trail[1]. According to Yli-Huumo et al. (2016), blockchain offers better security compared to traditional systems because no single entity has full control over the stored data, reducing the risk of attacks[2].

Several studies have examined the application of blockchain in the education sector. Grech and Camilleri (2017) emphasize that blockchain can be used to manage academic data, such as recording learning outcomes, certification, and student credentials. Grech and Camilleri (2017) also highlight

blockchain's ability to enhance trust and transparency between educational institutions and stakeholders[4]. Sharples and Domingue (2016) support this view, showing that blockchain can address issues of fraud and data manipulation in academic data management[5].

Blockchain-based academic information systems have begun to be implemented in various educational institutions to address security and transparency issues. A study by Devine (2018) highlights the implementation of blockchain at a university that successfully secured academic data from hacking and misuse threats[6]. Additionally, Ellis and Kent (2019) show that by using blockchain, educational institutions can provide more secure and transparent access to academic data, facilitating more efficient and reliable credential verification[7].

Data security is one of the most critical aspects of academic information systems. According to research by Ferreira et al. (2017), conventional academic information systems often face risks such as hacking, data theft, and information manipulation. Ferreira et al. (2017) also mention that although data encryption and access control can help, there are still limitations in maintaining data integrity and security[8]. Blockchain emerges as a potential solution by offering a secure and immutable recording system, as discussed by Zheng et al. (2017) [9].

Although blockchain offers various advantages, some studies also note challenges in its implementation. Yaga et al. (2019) highlight technical challenges such as large-scale data, the need for strong computing power, and high transaction costs in blockchain networks[10]. Additionally, Tapscott and Tapscott (2016) show that adopting blockchain in the education sector requires significant changes in information technology infrastructure and appropriate regulatory and policy support[11].

Several case studies of blockchain implementation in education provide valuable insights. Grech and Camilleri (2017) report that Malta has adopted blockchain to store and verify academic certificates. This shows how blockchain can be used to improve efficiency and security in academic data management[4].

Blockchain has significant potential in enhancing data security and transparency in academic information systems. The application of blockchain can address many challenges faced by traditional academic information systems, especially in terms of security and trust. However, technical and policy challenges need to be considered in practical implementation. It is necessary to develop more efficient and affordable solutions for implementing blockchain in educational institutions.

METHODOLOGY

This research uses the Rapid Application Development (RAD) method in the design and development of a Blockchain-Based Academic Information System. The RAD method was chosen for its ability to accelerate software development through rapid iterations and active user involvement. The RAD method adopted in this research includes requirements planning, user design, and construction.

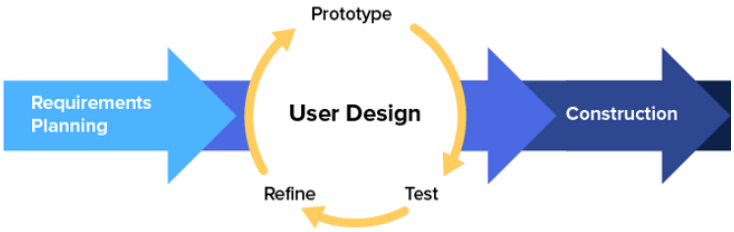

Figure 2. Rapid Application Development (RAD)

In the initial requirements planning stage, the identification and analysis of academic information system requirements at the educational institution where blockchain technology will be implemented

were conducted. Discussions with academic administrators, faculty, and students were held to identify specific needs related to data security and transparency. A requirements specification document was prepared, covering academic data management, decentralized storage, rights-based access control, and data verification.

The second stage, system design, involves creating a prototype that reflects the main functions of the blockchain-based academic information system. End users are directly involved in this stage to ensure that the design meets their needs and expectations. The initial prototype development includes the user interface, blockchain-based database structure, and basic system workflows. The prototype is created using mockup software and blockchain simulations. Users provide feedback on the prototype, which is then used to make iterative revisions and refinements until an appropriate design is achieved.

In the construction stage, the refined prototype is developed into a functional academic information system. Key modules such as academic data recording, data encryption and decryption, and blockchain consensus mechanisms are developed according to the approved design. Each module is tested to ensure it works according to specifications and meets user needs. Testing includes unit tests, integration tests, and system tests.

In the implementation and testing stage, the built system is implemented in a real environment and thoroughly tested to ensure all functionalities work well. The system is implemented at the educational institution that serves as the case study. Academic data is migrated to the blockchain system, and users begin using the system for daily academic data management. End users conduct system testing in real-use scenarios to ensure the system meets security and transparency needs. Security tests are conducted to identify potential vulnerabilities in the system, including penetration tests to test the strength of blockchain encryption and security mechanisms.

The RAD method enables the effective and efficient development of a blockchain-based academic information system by involving users in every development stage. The RAD approach ensures that the resulting system not only meets technical requirements but also operational needs, and can enhance data security and transparency in educational institutions.

RESULTS

The results of this research focus on the implementation of a Blockchain-Based Academic Information System to enhance data security and transparency in educational institutions. The developed system utilizes the Rapid Application Development (RAD) method and has been successfully tested in terms of technical aspects, functionality, and user satisfaction levels. The implementation of blockchain effectively maintains data integrity through a decentralized ledger and cryptography. The system is designed to store academic data such as student records, grades, class schedules, and certificates on an encrypted blockchain ledger. Each data change is recorded as a new, immutable transaction, ensuring data security and accuracy. Data security in this system is enhanced by blockchain technology, which relies on immutability mechanisms, where each transaction must go through a consensus mechanism such as Proof of Work (PoW). This approach ensures that academic data cannot be manipulated or altered without the majority consensus of nodes in the network, making the system more resistant to manipulation or hacking threats. Additionally, transparency is one of the main advantages of this system. By utilizing the blockchain network, all authorized parties, including administrators, faculty, and students, can verify the validity of academic data in real-time. This creates a higher level of trust in academic data management while simplifying the verification process without requiring third-party involvement.

System testing shows a significant improvement in academic data security compared to traditional centralized systems. Testing was conducted through various approaches to evaluate the system's resilience to security threats. Cyber-attack simulations or penetration testing were applied to identify potential security gaps. The results show that this system can withstand attacks, with no significant vulnerabilities found. Data encrypted in the blockchain is difficult to alter without the consensus approval of all nodes in the network, minimizing the risk of data manipulation or intrusion. Data integrity in this system is maintained by applying hashing algorithms. All stored academic data is

verified with hashing, ensuring no changes or falsifications can occur undetected. Any legitimate changes made are recorded as new blocks in the blockchain network, creating a transparent and immutable audit trail. Another advantage is the implementation of a decentralized system, which eliminates the risk of a single point of failure. In this system, data does not rely on a single central server but is distributed across all nodes in the network. This makes the system more resilient to disruptions or damage at a single point compared to traditional database systems, which are more vulnerable to such risks.

With this blockchain-based security approach, the research successfully demonstrates that the developed system is not only more secure but also more reliable in maintaining the integrity and availability of academic data. Functionality testing of the system was conducted in a simulated educational institution environment involving various parties, including administrators, faculty, and students. The test results show that the system can operate optimally and meet user needs in academic data management. The process of recording data such as grades, attendance, and academic certificates runs smoothly and efficiently. The system can receive data input at high speed without technical obstacles, demonstrating reliable performance in the simulated environment. The system's ability to verify the authenticity of academic data is one of its standout features. Users can easily ensure the validity of documents such as diplomas or transcripts through the blockchain network. This verification process increases user trust in academic data management because all information recorded on the blockchain is transparent and immutable.

In terms of processing time, the blockchain-based system shows good efficiency. Each transaction, such as data storage or verification, takes an average processing time of 1 to 3 seconds. This proves that the system can handle operations quickly and meets the needs of educational institutions that require managing large amounts of data with minimal response time. Overall, the test results show that the blockchain-based academic information system has strong functionality, with efficient performance and features that can enhance security and user trust in academic data management. The evaluation of transparency and user satisfaction levels was conducted through a survey involving 30 respondents from the educational institution, including administrators, faculty, and students. The survey results show that this system can provide a positive experience and meet user needs in various aspects. In terms of transparency, most respondents stated that this system provides a very high level of transparency. Academic data can be verified directly by users without involving third parties, increasing trust in the validity of the provided information.

Data security is also one of the main advantages recognized by the respondents. They feel safer using this system compared to the old system because blockchain technology prevents data leakage and manipulation. Respondents appreciated the system's ability to maintain the integrity and confidentiality of academic data. In terms of ease of use, the system interface is considered simple and intuitive, making it easy for users to perform various available functions. Most respondents feel that this system has been designed according to the needs of academic institutions, both in terms of features and accessibility. Overall, this evaluation shows that the blockchain-based academic information system not only meets the needs for security and transparency but also provides a good user experience through a user-friendly and efficient interface.

DISCUSSION

This research demonstrates that blockchain is highly effective in enhancing the security of academic data. The designed system utilizes a decentralized ledger mechanism to ensure data cannot be manipulated. Decentralized data storage eliminates vulnerabilities commonly found in centralized systems. This technology also adopts encryption techniques and hashing algorithms, providing an additional layer of data protection. In this system, consensus mechanisms such as Proof of Work (PoW) allow data verification by multiple parties in the network, making data manipulation nearly impossible. Transparency is a significant added value in managing academic data using blockchain. This system allows all authorized parties to verify data in real-time without third-party involvement. Each data change is automatically recorded in a new block, creating a complete and immutable audit

trail. This encourages increased user trust in the system's validity. Transparency also facilitates users in accessing and evaluating academic data, such as transcripts or diplomas, directly.

The Rapid Application Development (RAD) method proved highly effective in developing this system. Through rapid iteration, the system prototype can be continuously tested and improved based on user feedback. This process ensures that the resulting system meets user needs, especially administrators, faculty, and students. Additionally, this approach allows for system development in a shorter time compared to conventional methods, without compromising the quality of the final product. Compared to traditional academic information systems, the blockchain-based system shows significant advantages. The resulting data security is much higher because encrypted data cannot be altered without going through the consensus process. Transparency also increases, as data can be directly verified by authorized parties. Operational efficiency improves, with faster data management and reduced administrative burden.

However, this research also faces several challenges, such as the need for better network infrastructure to support blockchain technology. Additionally, users require special training to understand and optimally utilize this new technology. In terms of scalability, implementing this system in large-scale educational institutions may require additional development to maintain its performance. Overall, this research shows that the Blockchain-Based Academic Information System can significantly enhance data security and transparency. Although challenges such as infrastructure needs and user training remain, the results of this research provide a strong foundation for the application of blockchain technology in educational institutions. With further development, this system has great potential to become a standard solution in managing academic data that is more secure, transparent, and efficient.

CONCLUSION

This research demonstrates that the application of blockchain technology in academic information systems at educational institutions can significantly enhance data security and transparency. Based on the background highlighting the challenges of academic data security and the need for more reliable systems, this research successfully developed and tested an effective blockchain-based academic information system. Blockchain technology, with its cryptographic, hashing, and consensus mechanisms, has proven capable of preventing data manipulation. Each transaction recorded in the blockchain is immutable, ensuring the integrity and authenticity of academic data. System testing shows that data encrypted in the blockchain is difficult to alter without the consensus approval of all nodes in the network, minimizing the risk of data manipulation or intrusion. Blockchain provides full transparency in academic data management. All authorized parties can verify data in real-time without third-party involvement, increasing trust in data management. Transparency evaluation through surveys shows that users feel more confident with this system because academic data can be directly verified by users. The Rapid Application Development (RAD) method used in system development allows for rapid iterations and active user involvement, ensuring that the resulting system meets both technical and operational needs. The blockchain-based system shows efficient performance in academic data management, with fast transaction processing times and a user-friendly interface. The blockchain-based academic information system offers significant advantages over traditional systems, particularly in terms of security, transparency, data integrity, and resilience to disruptions. Comparative analysis shows that traditional systems are more vulnerable to hacking and data manipulation, while blockchain ensures that stored data cannot be modified once recorded. Although this research faces challenges such as the need for better network infrastructure and user training, the results provide a strong foundation for the application of blockchain technology in educational institutions. With further development, the blockchain-based academic information system has great potential to become a standard solution for managing academic data that is more secure, transparent, and efficient. Overall, this research confirms that blockchain technology can be an innovative solution to address the challenges of academic data security and transparency in educational institutions, providing significant benefits to all stakeholders.

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