Blockchain-Based Payment System for Registration Fees in higher education: A Case Study of Algeria

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Abstract

This paper describes the development and deployment of a blockchain-based payment system specifically intended to handle enrolment fees in universities, especially those in Algeria. The main goal is to eliminate the inefficiencies of conventional payment systems, which frequently entail labour-intensive processing by hand, lengthy processing times, and significant administrative costs. This system seeks to reduce reliance on banks and minimize processing errors by offering a safe, transparent, and automated fee payment platform through the use of blockchain technology. The suggested method automates real-time student registration changes, payment verification, and receipt issuance using Ethereum smart contracts. The system also seamlessly functions inside the academic ecosystem by integrating with the current university infrastructure, including the Financial Management System (FMS) and Student Information System (SIS). The system's capacity to shorten transaction times, improve data integrity, and offer scalability by utilizing Layer-2 technologies to handle large transaction volumes during peak times is demonstrated via a prototype implementation at Skikda University. The pilot program's results show notable gains in security and payment efficiency, and automatic auditing features guarantee openness for both administrative personnel and students. The system's scalability, compliance with legal requirements, and possibility across the state implementation across Algerian universities are all included in the study's conclusion. Future research will look into extending the system's capabilities to include more financial operations in the educational field.

Keywords

Blockchain, Smart contract, Registration, Payment

1. Introduction

Higher education institutions all over the world have had a difficult time updating their administrative procedures in recent years, especially with regard to payment methods. Conventional approaches to registration fee management frequently depend on manual processing, paper-based documentation, and centralized banking institutions [1]. These methods put students and universities at serious risk for fraud, data breaches, and lack of transparency in addition to being labor-intensive and prone to human mistake. The growing of universities and student bodies highlights the inefficiency of these outdated processes [2].

In Algeria, it is particularly important to have a reliable and safe method of paying registration fees, where many students have trouble using typical banking services, especially those who are studying abroad or in remote locations. Both students and university staff are burdened by the actual method, which frequently requires lengthy lines, exhausting documentation, and delays in payment processing. Furthermore, using centralized financial institutions introduces intermediaries, increasing the cost and duration of transactions [3]. These difficulties highlight the requirement for a cutting-edge and dependable system that can expedite payment processing, ensure security, and offer transparency. Blockchain technology has come to light as a possible fix for these problems, as a decentralized ledger system that was first created to support crypto-currencies like Bitcoin. It allows for safe, transparent, and immutable transactions. Blockchain can improve security, lower transaction costs, and speed payment procedures by eliminating intermediaries [4]. Every transaction made through a blockchain-based

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payment system is recorded on a distributed ledger, protecting sensitive financial information and guaranteeing transparency for both students and universities. The primary features of blockchain technology (Decentralization, transparency, and security) make it a good choice for handling financial transactions in higher education, such as registration fees [5]. Peer-to-peer transactions and cryptographic protocols used by blockchain technology also eliminate the need for conventional middlemen, reducing costs and speeding up transactions. Despite its potential, blockchain technology has not been widely incorporated into educational systems, due to the technological complexity of its infrastructure, which necessitates specialist knowledge for implementation and maintenance [6]. Especially in underdeveloped nations, educational institutions frequently lack the resources and technical knowledge necessary to implement blockchain solutions on a large scale. Moreover, network congestion and high transaction fees at peak times are potential consequences of scalability problems with public blockchains like as Ethereum, which could discourage adoption [6]. Significant challenges are also posed by regulatory issues, since many nations have unclear or restrictive laws governing the use of blockchain technology and crypto-currency in public institutions. Furthermore, integrating blockchain with current systems can be challenging. Since most universities use well-established Financial Management Systems (FMS) and Student Information Systems (SIS), integrating a decentralized blockchain system will need to be carefully planned and implemented to prevent upsetting current workflows. Despite these drawbacks, developments in smart contract platforms and Layer-2 solutions [7] are resolving some of these issues, increasing the scalability and accessibility of blockchain for use in educational applications.

This study investigates these advantages and suggests a blockchain-based payment method designed specifically for higher education in Algeria. Universities can track and verify payments in real-time and students can pay their fees using digital wallets on a transparent and secure platform made possible by the proposed system, which takes advantage of blockchain's decentralized nature. One of the system's main features is smart contracts, which are self-executing agreements that start transactions automatically when specific conditions are reached [8]. These contracts greatly reduce the administrative load on university employees by automating processes like payment verification, student record updates, and receipt issuing. The payment procedure is automated by the system, which not only increases efficiency but also reduces errors and delays, giving students an excellent experience. This article is guided by the following research question: How might blockchain technology enhance the effectiveness, safety, and openness of payments for registration fees in higher education? This article looks at how blockchain can be integrated with current payment systems to find ways to improve data integrity, speed up transactions, and reduce dependency on intermediaries. This study aims to: 1) Present the difficulties Algerian universities have in processing registration fee payments using conventional systems. 2) To suggest a blockchain-based method for safe, easy, and effective fee payments that makes use of digital wallets and smart contracts. 3) To demonstrate the system's possible advantages, such as improved security, less administrative work, and less transaction fees. With an emphasis on Algerian institutions specifically, this study seeks to give a thorough framework for adopting blockchain-based payment systems in higher education by addressing these goals. The conclusions and suggestions might act as a template for other organizations looking to use blockchain technology to enhance their financial processes.

2. Literature review

2.1. Current Payment Systems in Higher Education

Many payment methods are used by universities throughout the world to handle tuition payments and registration fees. The methods used in different regions differ greatly; while in developing countries like Algeria still use manual payment processes that involve cash payments and bank transfers.

2.1.1. Methods for Collecting Registration Fees

Universities in developed nations have widely adopted online payment systems, allowing students to access their accounts and pay with credit/debit cards; electronic funds transfers (EFTs), or digital wallets such as PayPal or Apple Pay. Automated billing solutions simplify the procedure for students and administrative staff by sending email or SMS reminders and allowing real-time payment tracking. Universities in nations such as Algeria, on the other hand, still mostly depend on conventional payment methods, like cash payments made in person or bank transfers [9]. Although dependable, these methods require manual verification by administrative staff and take a lot of time, which causes delays in registration confirmation. The reconciliation procedure is made more difficult and error-prone by the dependence on paper receipts as evidence of payment.

2.1.2. Current Systems' Issues

Traditional payment systems frequently encounter many problems, especially in areas that have not completely adopted digital methods:

1. Payment delays: Manual confirmation is frequently needed for cash payments and bank transfers, which causes delays in processing registrations and updating student accounts. Students have to many wait to receive payment confirmation in areas like Algeria where there is a lack of developed digital infrastructure.
2. Manual Interventions: Human error is more likely to occur in manual operations like bank reconciliation and check verification. The procedure is further slowed down by the need for additional administrative time to handle misattributed or missing funds.
3. Fraud and Security Risks: Conventional payment methods, especially those that depend on cash, are susceptible to fraud, including the falsification of payment receipts or illegal access to financial data. Cash-based systems are more vulnerable to theft or corruption because cash transactions are harder to monitor and secure. Without sufficient cyber-security safeguards, even digital systems are vulnerable to hacking, exposing financial data to unauthorized access.

2.2. Blockchain Technology in Financial Systems

Blockchain technology, initially developed as the underlying infrastructure for crypto-currencies like Bitcoin [10], has rapidly evolved into a transformative technology in financial services. Its decentralized nature, coupled with the immutability and transparency of distributed ledgers, offers a solution for addressing many of the inefficiencies in traditional financial systems.

2.2.1. Blockchain Applications in Financial Services

Financial services including digital identity verification, securities trading, and cross-border payments have effectively used blockchain technology. Its decentralized nature reduces intermediaries' need, which lowers transaction costs and speeds up processing. Banks can now settle international transactions in real-time, cutting settlement periods from days to seconds, thanks to Ripple's blockchain [11]. Blockchain is a desirable option for handling payments in education because its cryptographic security guarantees that transactions are immutable and tamper-proof [12]. Another innovation that increases process efficiency is the use of smart contracts, which eliminate the need for third-party verification. In financial services, they reduce delays and administrative hassles by automating the verification of tuition payments and updating student records in real-time [13].

2.3. Blockchain in Education

Blockchain's potential extends beyond financial into education sector, where it is increasingly being explored for applications such as credential verification and student data management [14].

2.3.1. Credential Verification and Data Storage

Blockchain's decentralized ledger provides a tamper-proof way to store and verify academic credentials. Projects like MIT's Digital Diploma [15] and Sony Global Education [5] have pioneered blockchain-based systems for storing academic records. These systems allow students to maintain lifelong control over their credentials, while universities and employers can verify qualifications directly on the blockchain. Because blockchain data is distributed across multiple nodes, altering or deleting records without consensus is nearly impossible, making it ideal for securely maintaining long-term student records [16].

2.3.2. Blockchain for Payments and Record Management in Education

Blockchain has also been piloted in higher education for simplifying payments and managing student records. The University of Nicosia in Cyprus was one to accept Bitcoin for tuition payments, highlighting blockchain's potential to reduce costs and increase security in financial transactions [17]. More recent projects have explored the use of decentralized ledgers to unify payments systems with student enrolment records, allowing for a seamless, transparent, and secure system to track payment academic progress [18].

### 2.3.3. Limitations and Challenges of Blockchain Adoption in Education

While blockchain holds significant promise, its adoption in education has been slow due to several challenges: Adoption of blockchain in education confronts a number of obstacles, including as integration with current systems, high energy consumption, and legal and regulatory barriers. For large-scale applications, blockchain systems—especially those that use Proof-of-Work (PoW) consensus mechanisms like Bitcoin are unsustainable, especially in nations with limited energy resources [10]. Although they provide more energy-efficient solutions, alternative consensus techniques like Proof-of-Stake (PoS) are not yet commonly used [19]. Legal and regulatory obstacles are another problem because blockchain technology is still in its infancy in many nations; some governments support it while others place limitations or outright prohibitions on it. The usage of crypto-currency is prohibited in Algeria, for instance, which makes it difficult for colleges to implement blockchain-based financial systems [20]. In order to maintain compliance with financial rules, cyber-security requirements, and data protection legislation, educational institutions need to navigate through intricate regulatory frameworks. Because it requires substantial investment and technical expertise to adapt existing university systems, such SIS and FMS, to function with decentralized blockchain networks, integration with these systems offers considerable obstacles. Blockchain technology might produce parallel systems without the right integration, which would increase inefficiencies rather than reduce them [21]. Scalability concerns also pose a challenge, as public blockchains like Ethereum can become congested during high demand periods, resulting in slow transaction times and increased costs. Layer-2 solutions and private blockchains offer potential remedies, but their implementation requires further research and testing [22].

3. Proposed System

A blockchain-based registration fee payment system in higher education offers a decentralized, safe, and transparent alternative to traditional payment methods. Utilizing digital wallets, smart contracts, and a decentralized ledger, the system automates and simplifies fee collection, reducing manual intervention and removing the need for third-party involvement. It ensures secure, immutable storage of transactions.

3.1. System Architecture Overview

Three key elements make up the proposed system: digital wallets for the storage and transfer of student funds, smart contracts for automated fee payment management, and a decentralized ledger for transaction recording. By avoiding the need for central authorities to maintain security and transparency, the system will enable fast, safe, and transparent transactions between students and universities.
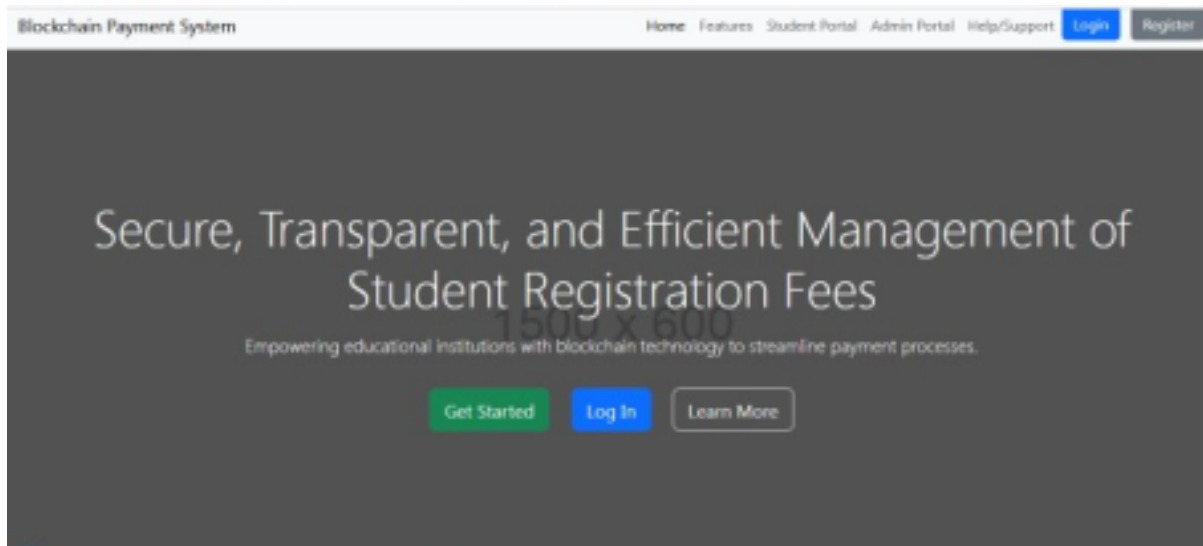
Figure 1: Portal University's home page

3.2. Key Components of the Architecture

3.2.1. Digital Wallets for Students

Each student is assigned a digital wallet to store funds in crypto-currency or fiat currency, linked to their university account [23] [24]. Students can add money to and check the amount of these wallets via a mobile app or university portal (see 1). The digital wallet initiates the transaction, which is safely completed via the blockchain, when it is time to pay registration fees. The wallet is secured using cryptographic keys, guaranteeing that only the student can access it. Additionally, it interacts with smart contracts on the blockchain to automatically deduct and credit the appropriate fees to the university's account. To pay fees, students simply create and register their wallets, add money to them using credit cards, bank transfers, or crypto-currency, and link their wallets to smart contracts.

3.2.2. Smart Contracts for Payment Automation

Smart contracts are blockchain self-executing code and enforce conditions automatically, such as paying registration fees. These contracts guarantee that, upon accomplishment of certain requirements, the necessary fee is transmitted to the university's account and is deducted from the student's digital wallet. Conditions such as guaranteeing adequate cash and validating registration information are programmed into the smart contract that can also modify the student's registration status in the university's system and initiates the automatic transfer of funds to the university upon accomplishment of all requirements. This automation reduces fraud and errors while enhancing the speed and efficiency of the payment process by eliminating the need for manual verification or third-party involvement.

3.2.3. Decentralized Ledger for Secure and Transparent Payments

The system records each registration fees transaction on a decentralized ledger known as blockchain. As a distributed ledger, this solution gives access to a secure, immutable record of transactions to all parties involved, including universities, students, and government agencies. Every transaction is recorded on file as a time-stamped block to prevent tampering or deletion, guarantying the integrity and security of the payment process. This system also provides Real-time transparency, which enables administrators and students to monitor payments and resolve fee issues. Additionally, auditors or governmental organizations can easily monitor the ledger for regulatory compliance. This decentralized ledger is scalable, making it suitable for use across entire higher education ecosystems with numerous universities and large student populations.

4. Workflow of the System

4.1. Registration and Digital Wallet

During the registration period, students register on the university's blockchain-based platform by creating an account that securely liked to a digital wallet, which they may recharge with crypto-currency or fiat money (e.g Algerian dinar) through a bank or third-party payment gateway.

4.2. Initiation of Payment via Smart Contracts

The student uses the university portal to initiate payment after selecting their alternatives for tuition and registration fees. Based on the student's profile, the amount due, and any conditions (e.g., payment deadlines) an automatic smart contract. The smart contract verifies that all requirements are satisfied and determines if the learner has enough money in their digital wallet.

4.3. Transaction Processing and Ledger Recording

After being checked, the smart contract carries out the payment transaction, and the funds are transferred from the student's wallet to the university's designed account. The instantaneous recording of the payment on the blockchain ledger guarantees complete transparency and transaction traceability. A digital receipt for the transaction is sent to the university and the student.

4.4. Automatic Registration Confirmation

The smart contract updates the student's registration status in the university system after successful payment processing, and a cryptographically signed certificate of registration is given to the student and is stored on the blockchain for future use.

4.5. Follow-up and Reporting

Through the blockchain ledger, universities can access real-time reports of all payments, reducing administrative burden and guarantees accurate financial records. The same digital wallet system can be used by institutions and students to use the portal for additional payments, such as course fees or other services.

For more understanding the proposed system flow, the figure bellow presents a simplified description from the student to the university flow (see Fig 2).

5. System's implementation in Algerian Universities

5.1. Context Overview

With around 86 state universities serving about 1.8 million students, Algeria boasts a varied higher education scene [25]. However, there are still a lot of obstacles because the payment system is still mostly dependent on conventional methods:

5.1.1. Reliance on traditional banking

Due to the fact that most students must visit banks to complete transactions, there are typically large lines and wait durations of 2 to 4 hours each visit. In addition to delaying registration, this also makes students more irate and less satisfied with their university experience.
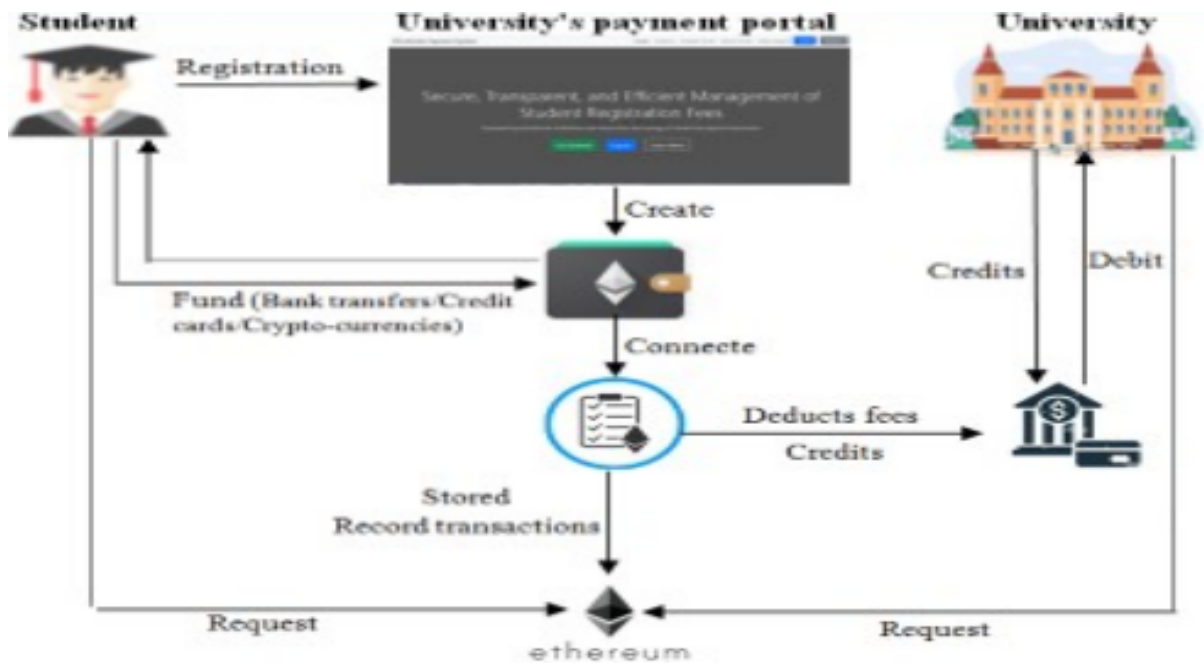
Figure 2: Simplified description of the proposed system flow

5.1.2. Limited Digital Payment Options

Just 15% of Algerian institutions had fully digital payment systems in place as of 2024 [25]. This leads to a significant digital gap, particularly for students who may not have easy access to financial services because they attend school in remote places. On the other hand, over 60% of institutions in nations like Morocco and Tunisia have implemented digital payment systems, enabling smooth transactions using mobile apps and web portals [26][27].

5.1.3. Manual Processing and Error Rates

An approximate 10% mistake rate results from the manual entering of payment data, with typical problems including misattributed payments or delayed changes in student accounts. The administrative team is burdened by this inefficiency and must fix the mistakes, which slows down the registration process even further.

5.2. Comparative Analysis

An approximate 10% mistake rate results from the manual entering of payment data, with typical problems including misattributed payments or delayed changes in student accounts. The administrative team is burdened by this inefficiency and must fix the mistakes, which slows down the registration process even further.

5.3. Proposed Deployment Strategy

The adoption of a blockchain-based payment system is essential given these obstacles:

5.3.1. Training for Staff and Students

To acquaint university personnel and students with digital wallets and blockchain technology, training courses will be necessary. The goal of this proactive strategy is to boost trust in the new system.

5.3.2. Pilot Programs

To test the suggested system, the Algerian university of 20th August, Skikda established the first pilot program at the start of the 2024–2025 academic year. This schedule enables thorough testing and a phased deployment over the foreigner languages department. Before a more widespread deployment, these pilots will assist in improving the system and addressing any potential issues following these phases:

In June 2024, University prepared for the launch of the proposed system, focusing on digital wallets, smart contracts, and secure transaction logging. Administrative and IT personnel received extensive training on managing smart contracts, running the blockchain, and assisting students with using digital wallets to pay for fees. In July 2024, the emphasis shifted to student orientation to ensure they were prepared to use the system. A special help desk was set up to offer technical support during orientation. In August 2024, the initial deployment focused on first-year foreign language students at the Faculty of Arts and Foreign Languages to test the system's scalability. Monitoring was a key priority, with attention paid to payment processing speed and student satisfaction. Continuous performance tracking helped identify potential issues early and ensure the system was running efficiently before expanding to other student groups. In September 2024, the focus shifted to the evaluation phase of the pilot program, with data analysis conducted to assess key metrics such as transaction success rates, system performance, and student adoption. Adjustments were made mid-project, and feedback from students and staff was directed to improvements to ensure smoother operation and optimized user experience before further expansion.

A comprehensive program assessment was conducted at Skikda University, analyzing the system's functionality, student adoption, transaction success rates, and operational challenges. A detailed report was prepared outlining the results and suggesting adjustments for future expansion, serving as a guide for scaling the system to other universities across Algeria.

6. Evaluation and Results

Promising outcomes were found when the suggested system pilot at Skikda University was evaluated in terms of user adoption and transaction efficiency. Nonetheless, a number of technological difficulties and hazards were noted; these must be resolved to guarantee the system's long-term viability and scalability.
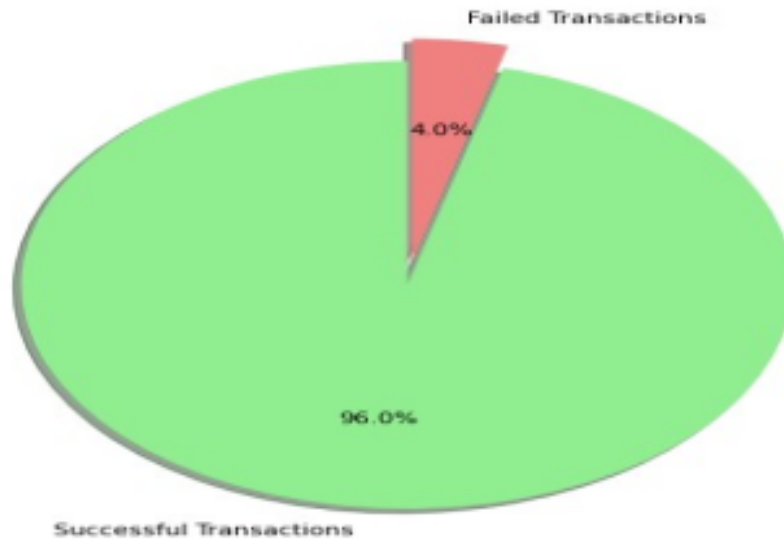
6.1. Transaction Success Rates

Throughout the pilot phase, the system achieved an overall transaction success rate of 96% (see 3), indicating that the proposed solution is largely reliable. Technical problems included insufficient wallet balances from students not knowing how to load their digital wallets or connectivity problems between the blockchain network and the university's system, which occasionally caused delays in updating student registration statuses, were blamed for the 4% failure rate.

6.1.1. Technical Challenges

The pilot of the proposed system in Algerian universities has revealed several technical challenges that need further refinement before broader deployment. Smart contract bugs, which result from poorly defined conditions or incorrect parameters, were addressed through rigorous testing and code audits. System downtime was experienced during peak usage periods, with the underlying blockchain network becoming congested, leading to delays in processing payments and student registration. Layer-2 solutions like Optimism were explored to offload transaction processing from the main Ethereum blockchain, allowing the system to scale without sacrificing speed or reliability. Blockchain network latency was another concern, with transactions taking 5-15 minutes to be fully verified. Private or consortium blockchains are being considered to reduce transaction confirmation times while leveraging

Figure 3: Transaction success rates during initial pilot

blockchain technology's transparency and security. Integrating the blockchain-based system with legacy systems was challenging due to differences in data structures and protocols. Middleware solutions were developed to facilitate seamless data flow and ensure real-time updates. Future iterations will need to refine this integration further.

6.1.2. Potential Risks

In addition to the technical challenges encountered, several potential risks need to be considered for future deployment. The Algerian university system is deploying smart contracts, which are immutable and cannot be easily fixed post-deployment. This poses a significant security risk as malicious actors could exploit these weaknesses. To mitigate this, comprehensive audits by third-party security experts and formal verification techniques are crucial. Continuous monitoring and upgradeable smart contracts could also offer flexibility for patching bugs.

Public blockchains like Ethereum are susceptible to network-wide events, which could disrupt the payment process if the system relies on a public network. Implementing redundant systems and leveraging private blockchain networks within the Algerian university system can minimize these risks. Real-time monitoring of the blockchain network is essential for mitigating any downtime.

User errors, such as losing access to digital wallets or sending payments to incorrect addresses, can be reduced by providing extensive training and user support. Implementing a multi-signature wallet system can also prevent unauthorized transactions. Finally, regulatory uncertainty is another concern, as the lack of a clear regulatory framework for blockchain and crypto-currency use in Algeria could introduce legal risks, especially in cases involving crypto-backed transactions.

6.2. User Adoption

To assess the effectiveness and user satisfaction of the proposed system, a survey was conducted during the pilot program at Skikda University. This section outlines the methodology, respondent demographics, and data analysis presented in Figures (4 and 5). The survey was administered online using to ensure accessibility and anonymity. Invitations to participate were sent via email to students and administrative staff directly involved in the pilot phase. The survey consisted of 15 questions, combining Likert-scale items to measure satisfaction levels, multiple-choice questions to assess ease of use and perceived efficiency, and open-ended questions to collect qualitative feedback. By combining these three types of questions, the survey aims to capture both quantitative data (numbers, statistics)
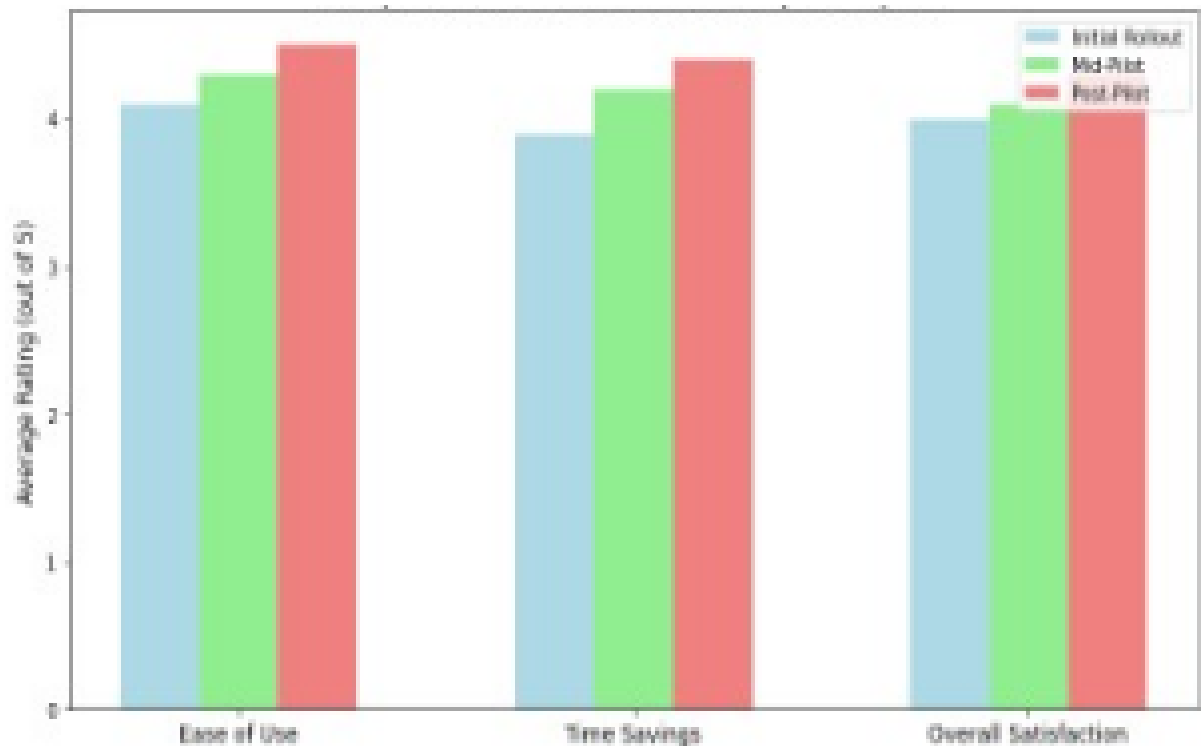
Figure 4: Survey results for the proposed system

and qualitative data (detailed opinions). This provides a comprehensive view of the system's strengths and weaknesses and helps to better understand user experiences. The questions focused on: Usability of the digital wallet and portal interface, Perceived improvements in payment processing time, Satisfaction with error resolution and transparency features, and Overall impressions of the system's effectiveness compared to traditional methods.

The survey received a total of 812 responses, comprising:

1. Students: 789 respondents (97% of the total), predominantly first-year foreign language students, as they were the primary users during the pilot phase. Most participants were between 18 and 25 years old, representing a wide range of familiarity with digital payment technologies.
2. Administrative Staff: 23 respondents (3% of the total), including financial officers and IT support staff, who provided insights into system integration and operational challenges

The survey results were analyzed to gauge the system's usability, reliability, and time-saving potential. Key findings include:

1. High satisfaction rates: Over 85% of respondents rated the system as "Good" or "Excellent" in terms of user experience.
2. Reduced processing times: The average time for fee payment decreased from several hours (traditional methods) to less than 15 minutes.
3. Ease of use: While 78% of respondents found the system intuitive, 22% expressed a need for additional training, particularly on wallet setup.

The feedback was instrumental in identifying areas for improvement, such as enhanced user orientation and addressing occasional system connectivity issues.

7. Benefits of the proposed System

The use of a blockchain-based payment system for registration fees ensures a more effective, safe, and transparent financial procedure, for students, universities, and government oversight organizations.
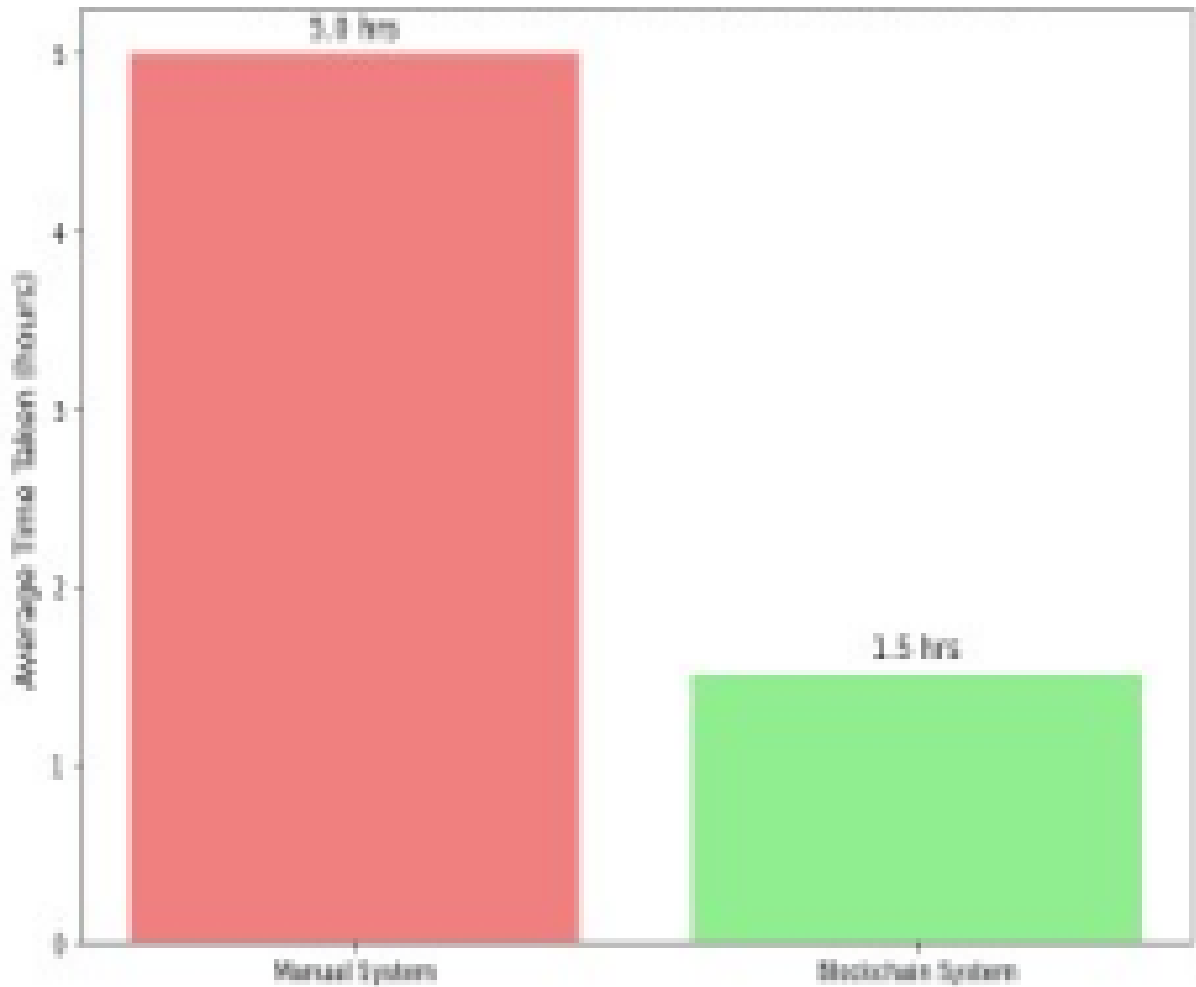
Figure 5: Time taken in fee collection

7.1. For Students

Blockchain technology offers students faster and more convenient payment options, bypassing the lengthy and error-prone processes of traditional banking systems. For example, at the University of Nicosia, students can complete payments in minutes, reducing processing times by 50%. [17] In Algerian universities, the blockchain system can reduce the average payment time from 5 hours to less than 15 minutes, enhancing the student experience, especially for international and remote students. Blockchain eliminates the need for intermediaries like banks, which often charge high fees for processing payments [17]. This is particularly beneficial for international students, who face high fees and currency conversion costs when making cross-border transactions through traditional banks. Blockchain also provides immutable, transparent payment records, providing a permanent, verifiable record of all financial transactions. This feature has been successfully implemented at MIT, where blockchain is used to issue digital diplomas and maintain a transparent record of academic credentials [15].

7.2. For Universities

Blockchain technology has revolutionized the financial sector by providing real-time visibility into incoming funds, enabling administrators to track payments in real-time [17]. This has improved operational efficiency by over 30% and reduced errors. In Algeria, implementing a similar system would allow smart contracts to automatically verify payment conditions and trigger updates in the university's Student Information System. This would eliminate the need for manual verification and data entry [17].

Blockchain technology also enhances fraud prevention by ensuring transactions are securely recorded and cannot be altered [15]. For instance, at MIT, blockchain is used for issuing digital diplomas and ensuring the authenticity of financial records. Implementing blockchain in Algerian universities could significantly reduce the risks of financial fraud, such as falsified payment receipts or manipulation of student records, leading to greater trust in Algerian higher education institutions' financial systems.

7.3. For Government and Oversight Bodies

Blockchain technology offers enhanced transparency and accountability for governments and regulatory bodies. Estonia's education system uses blockchain to maintain auditable records of student data and financial transactions, ensuring proper use of public funds and university compliance with regulations. Algerian universities can benefit from blockchain's transparency and accountability, making it easier for government bodies to audit university finances and track revenue [28]. Blockchain's ability to provide a single, immutable source of truth simplifies the auditing process, reducing time and resources needed for verification and ensuring compliance with financial regulations [15][29].

7.4. Case Study: University of Nicosia

The University of Nicosia, the first university to accept Bitcoin for tuition payments, has implemented a blockchain-based payment system. This system has resulted in a 50% reduction in processing times, a 30% reduction in administrative workload, and enhanced security and transparency [17]. The proposed system could be integrated into Algerian universities, enhancing financial and administrative operations, leading to greater efficiency, lower costs, and improved user satisfaction. This innovative approach could significantly benefit higher education institutions worldwide.

8. Future Work and Extensions

The proposed blockchain-based system for university payments has the potential to expand beyond registration fees to include tuition fee payments, exam fees, and digital certificates. This would streamline the process, reduce administrative delays, and improve efficiency. Blockchain technology's decentralized nature could also be integrated with international systems, simplifying cross-border payments and facilitating easier transfer of academic records and scholarship funds. However, further research is needed to evaluate the effectiveness of blockchain in reducing fraud, examine efficiency gains, and assess energy consumption. Additionally, research should explore student and staff adoption rates, assessing ease of use and potential barriers to widespread deployment. Overall, the potential benefits of blockchain for university payments are significant and warrant further exploration.

9. Conclusion

For Algerian universities, the suggested system offers a potential way to control registration fees. It deals with problems such payment processing delays, dependency on conventional banking infrastructure, and opaque fee collecting. Students' digital wallets, automatic fee payments via smart contracts, and transaction tracking via a decentralized ledger are all features of the system. Real-time payment processing and fast registration status confirmation are two ways that this system might improve the educational experience for students. It also makes it possible for university employees to track finances more effectively and comply with regulations, which lessens their administrative workload. However, pilot projects, staff and student training, and familiarity with the regulatory and legal framework are necessary for successful implementation. The adoption of blockchain technology in higher education is consistent with the global financial services industry's digital transformation trend. Universities in Algeria have the opportunity to streamline internal operations and establish themselves as pioneers in the digital era of learning. Future studies ought to examine this solution's scalability as well as its long-term effects on student happiness and institution operations.

10. Appendices

Appendix A: Dataset Structure

The dataset used in the study consists of:

1. **Student Records:** Includes registration details, fee statuses, and academic profiles of first-year students.
2. **Key Features:**
   - Core identifiers: Student ID, department, and year of study.
   - Financial data: Registration fees, payment timestamps, and digital wallet transactions.
   - System usage metrics: Transaction success rates and response times.

Appendix B: Technical Specifications

The proposed system operates with the following specifications:

1. **Blockchain Framework:** Ethereum-based smart contracts using Solidity.
2. **Digital Wallet:** Cryptocurrency and fiat integration via MetaMask.
3. **Testing Environment:**
   - Processor: Intel Core i7, 3.4 GHz.
   - RAM: 16 GB.
   - Blockchain Node: Ganache test network for prototype implementation.
4. **Middleware:** APIs for integrating the blockchain ledger with the university's Student Information System (SIS).

Appendix C: Survey Methodology

A survey was conducted to evaluate user adoption and satisfaction:

1. **Sample Size:**
   - 789 students from first-year foreign language programs.
   - 23 administrative staff members.
2. **Key Questions:**
   - Ease of use of digital wallets and portal interface.
   - Perceived improvement in payment processing times.
   - Satisfaction with error resolution and transparency features.
3. **Survey Format:** Online questionnaire combining Likert-scale items, multiple-choice questions, and open-ended feedback.

Appendix D: Dataset Structure

Below is a simplified pseudocode for the smart contract used to automate payment verification:

Acknowledgements

```
pragma solidity ^0.8.0;

contract UniversityPayment {
    mapping(address => uint256) public balances;

    function payFees() public payable {
        require(msg.value > 0, "Insufficient payment.");
        balances[msg.sender] += msg.value;
        // Logic to update student registration status
    }
}
```

Declaration on Generative AI

The authors have not employed any Generative AI tools.

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