Blockchain Framework for Examination Result Processing System for a Kenyan University

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ABSTRACT
The purpose of this study was to propose a Blockchain framework for decentralising the examination result processing system in a Kenyan university. The study used a pragmatic research approach involving qualitative and quantitative methods. The target population was comprised of lecturers and examination administrators at the university. The sample size was 297 respondents, and the results were derived using the Taro Yamens formula from the study population. Stratified sampling was used on lecturers, and purposive sampling was used on Examination administrators. Data was collected using questionnaires and interview schedules. Interviews were conducted with the examination administrators, while questionnaires were administered to lecturers. The data was analysed using inferential statistics for the quantitative data and thematic analysis for quanlitative data, respectively. The findings affirm that Blockchain technology aligns with the objectives of improving system integrity and security, making it a compelling solution to consider and propose within a university's academic ecosystem. Blockchain technology also has the potential to address key concerns and align with the desires of users for a more robust and trustworthy examination result processing system in a university. This study recommends adopting the Blockchain Technological Framework for the Examination Result Processing System to enhance integrity and security. Further research can be done on designing and developing the Blockchain examination result processing system, which can be integrated into the higher education examination result processing systems. This research is a valuable resource for academics, practitioners, and policymakers, offering insights to inform decision-making and advance the subject matter.

Keywords
Blockchain, framework, examination, processing, decentralisation, integrity, security

1. INTRODUCTION
Blockchain is a distributed information framework that decentralises digital contracts and intellectual assets. Documents are created by developers and verified by approvers in a peer-to-peer network that works without a third-party agent to authenticate the processes (Nizamuddin et al., 2019). Blocks of records are distributed as a public ledger of all the processed information executed and shared among participating nodes within the network. The peers in the Blockchain network are in constant negotiations to maintain asynchronous replication of transactions with blocks chained in order of creation (Nguyen et al., 2021). Therefore, every processed information in the ledger is verifiable by the majority of the participants within the chain (Sedlmeir et al., 2022).

Blockchain connects peers and processes new data validated according to pre-agreed instructions. These processed data are configured in the system and then stored and broadcast to all the participants to ensure that every node retains the current data in the platform. (Mohammed & Hashim, 2023). This protocol enables a more efficient, transparent, and trustworthy flow of transactions by omitting the central agent while maintaining privacy, immutability, and data confidentiality (Irannezhad & Faroqi, 2021). It is difficult to erase once the information or data is entered. Thus, Blockchain technology assures the integrity of the information by signing smart contracts through the chain's private and critical public infrastructure. Nevertheless, the immutability criteria of blocks of chains have emerged in debate.

According to Wang (2024), Blockchain technology has lots of opportunities, and the development surrounding the technology has just begun in the world today across various countries. It can revolutionise the field of records management by enabling a distributed consensus where every processed information, whether past or present, involving digital assets, can be verified at any time. This happens without manipulating the privacy of the digital information, and the people involved use advanced crypto graphical analysis to secure all the people involved in the distributed ledger (Baiod et al., 2021). The distributed consensus, which ensures the system is resilient to anonymity and manipulation, is one of the vital essential elements of the Blockchain system. Other areas where Blockchain can be applied include private securities, royalty payments in the music industry, attorney documents, health records, marriage licenses, and online examination result processing systems that can be processed through the underlying Blockchain technology.

In a study by Alammary et al. (2019) on a systematic review of Blockchain applications in education, most institutions are using Blockchain technology to process academic transcripts and certifications, store and share competencies and learning outcomes, evaluate student professional ability, and secure collaborative learning environments where learners are involved in peer-to-peer learning processes. Blockchain technology can help solve some of the problems of online education exam result processing systems, namely data security and integrity.

2. LITERATURE REVIEW
A Blockchain is a distributed database of records or a public ledger of all transactions or digital events executed and shared among participating parties (Islam & Shin, 2019). The consensus of most of the participants in the system verifies each transaction in the public ledger. Information can never be erased once entered into a Blockchain platform(Niranjanamurthy et al., 2018). The Blockchain contains a specific and verifiable record of every single transaction. As compared to a conventional centralised database, the information cannot be manipulated due to the Blockchain's built-in distributed nature of structure and

confirmed guarantees by peers. In other words, when a standard centralised database is located on an individual server, the Blockchain is distributed among the software nodes (Sarmah, 2018).

Blockchain allows any authorised user on the network to access everyone else's entries, making it impossible for one central entity to gain control of the entire network. Whenever a user performs a transaction, it goes to the network, and computer algorithms determine the transaction's authenticity. Once the transaction is verified, this new transaction is linked with the previous transaction's genesis block (Saxena & Laroiya, 2020), forming a chain of transactions that constitutes the Blockchain. Blockchain has the property of a database, except that it stores much more information in the header, and data is stored as a token (Casino et al., 2019). It is required to group the newly validated transactions into blocks as the first step of recording transactions in the ledger. Any participant in the Blockchain can gather new transactions and create blocks that can be appended to the Blockchain. A block mainly consists of transactions and has a pointer, timestamps and the nonce (Sarmah, 2018; Nizamuddin et al., 2019). A nonce, an abbreviation for 'number used once', is a random number generated through an algorithmic function and attached to modification of the previous block to prevent replay (Jain & Chandavarkar, 2021). One of the most significant advantages of Blockchain is dissemination, which allows a database to be shared without a central body or entity. Because of the decentralised nature of the Blockchain, it is almost impossible to temper the data compared to the conventional database. Users are empowered to control their information and transactions. Blockchains provide complete, consistent, and up-to-date data. Since Blockchain has no central point of failure due to its decentralised network, it can withstand most security attacks (Reis-marques & Figueiredo, 2021). There is no need for a centralised authority, and users can be confident that their transactions will be carried out as protocol commands. Blockchains provide transparency and immutability to the transactions as all the transactions cannot be altered or deleted without negotiation. The utilisation of Blockchain has moved beyond digital currency to other fields, such as health, the Internet of Things, and education (Awaji et al., 2020).

In education, Ubaka and Azeta (2020) propose a Blockchain-based E-learning framework to ensure the authenticity of the different students within the E-learning platform. It is a framework that ensures that only authorised students can access it and get resources from the platform. It also ensures security and privacy against threats experienced with the different E-learning platforms. Another Blockchain framework proposed by Srivastava et al. (2019) is a framework that is used to issue certificates in the various academic institutions of higher learning. This proposed framework ensures the decentralisation of certificates within the system, which helps keep the issuer and receiver together with a hashed signature to ensure the certificate's authenticity. A study by Alam et al. (2021) also proposes a Blockchain framework for issuing and verifying academic certificates through the distributed ledger. However, these systems do not cover the examination result processing used to certify students at the end of the education process as to whether they have failed or passed. Blockchain will benefit the educational system in a variety of ways. The technology is ideal for securely storing, exchanging, and networking sensitive data. With the help of this advanced device, many systems can be made faster, simpler, and better. It bridges the gap between integral results processing, credentialing, copyright, and fast connectivity. Blockchain technology has the potential for its application within the framework of managing the student's results to ensure the results' authenticity, security and integrity.

One potential research gap in the above text could be the lack of empirical research on the implementation and effectiveness of Blockchain technology in the education sector, especially in the result processing systems. While there have been several proposals for using Blockchain in education, there is a lack of empirical evidence on these implementations' practical applications and outcomes. Additionally, there may be a lack of research on the potential challenges and barriers to implementing Blockchain technology in education and strategies for overcoming these challenges. There is also a need for more research on how Blockchain technology can be effectively integrated into the existing educational system and how it can enhance existing educational practices and processes.

3. STATEMENT OF PROBLEM

Blockchain technology has expanded from digital currency to other areas, such as health and education (Awaji et al., 2020). Blockchain can benefit education, especially in managing higher-education institutions' examination results. The Technical University of Kenya (TUK), a young university with a centralised management structure, provided an ideal environment for the study of implementing Blockchain technology in its result-processing system.

TUK uses the Moodle platform to teach and conduct online and physical assessments. Once assessments are completed, the lecturer must transfer the grades to the Examination Data Processing System (EDPS), which processes continuous assessments and end-of-term exams. However, the centralisation of the examination systems poses a threat to manipulation at various stages, potentially compromising the integrity of the results. The current centralisation of the system also means that errors during data entry or processing or system administrators' compromise can compromise the results' security and integrity. In response to these challenges, the researcher proposes a Blockchain framework to decentralise the results during processing, which is the study's main objective, thus ensuring integrity and authenticity in the examination result processing system at TUK.

4. RESEARCH METHODOLOGY

The research utilised a pragmatic paradigm and a mixed methods approach, incorporating both qualitative and quantitative research methods. This approach aimed to provide a comprehensive understanding of the design problem and the impact of the design solution. The combination of qualitative and quantitative methods allowed for a deeper understanding of the context surrounding the design solution, taking into account social, cultural, and economic factors that influence user experience.

The study focused on lecturers and examination administrators as the target population. Two sampling techniques were employed: stratified random sampling and purposive sampling. Stratified random sampling was used to ensure adequate representation of each group within the sample, thereby increasing result accuracy and representativeness. This technique was applied to gather data from the lecturers. On the other hand, purposive sampling was used to specifically select individuals relevant to the research question, such as the examination administrators.

Data collection involved using questionnaires for the lecturers and structured interviews with the examination administrators, of which 30 individuals participated. The interviews were conducted in person.

The data analysis techniques comprised statistical and thematic analysis. Additionally, the response rate, representing the ratio of completed data collection tools to the calculated sample size, was reported to be 79%, with 211 completed questionnaires out of 267. Furthermore, 22 out of the 30 examination administrators participated in the interviews.

5. PRESENTATION AND DISCUSSION OF THE FINDINGS OF THE STUDY

The different respondents gave the following response regarding adopting Blockchain technology into the examination result processing system. As shown in Table 1 below, 70% of the respondents agreed with adopting the Blockchain technological framework to be embedded in the current examination system, while 30% disagreed with adopting Blockchain technology in the examination result processing system. In the various categories, as shown in Figure 1 below, Assistant Lecturers (μ=4, σ=0), Associate Professors (μ=4, σ=0), and Lecturers (μ=4, σ=0) all have the highest mean score of 4, indicating a high level of acceptance or positive attitudes toward Blockchain technology and the standard deviation of 0 suggests that all responses within these groups reported the same score, indicating consistent attitudes. Graduate Assistants (μ=3.25, σ=0.43) and Tutorial Fellows (μ=3, σ=0) have slightly lower mean scores, suggesting a relatively lower level of acceptance compared to the other three groups.

Table 1: Blockchain adoption response rate

Response	Percentage (%)	Number of Respondents
Agreed with adoption	70%	148
Disagreed with adoption	30%	63
Total	100%	211

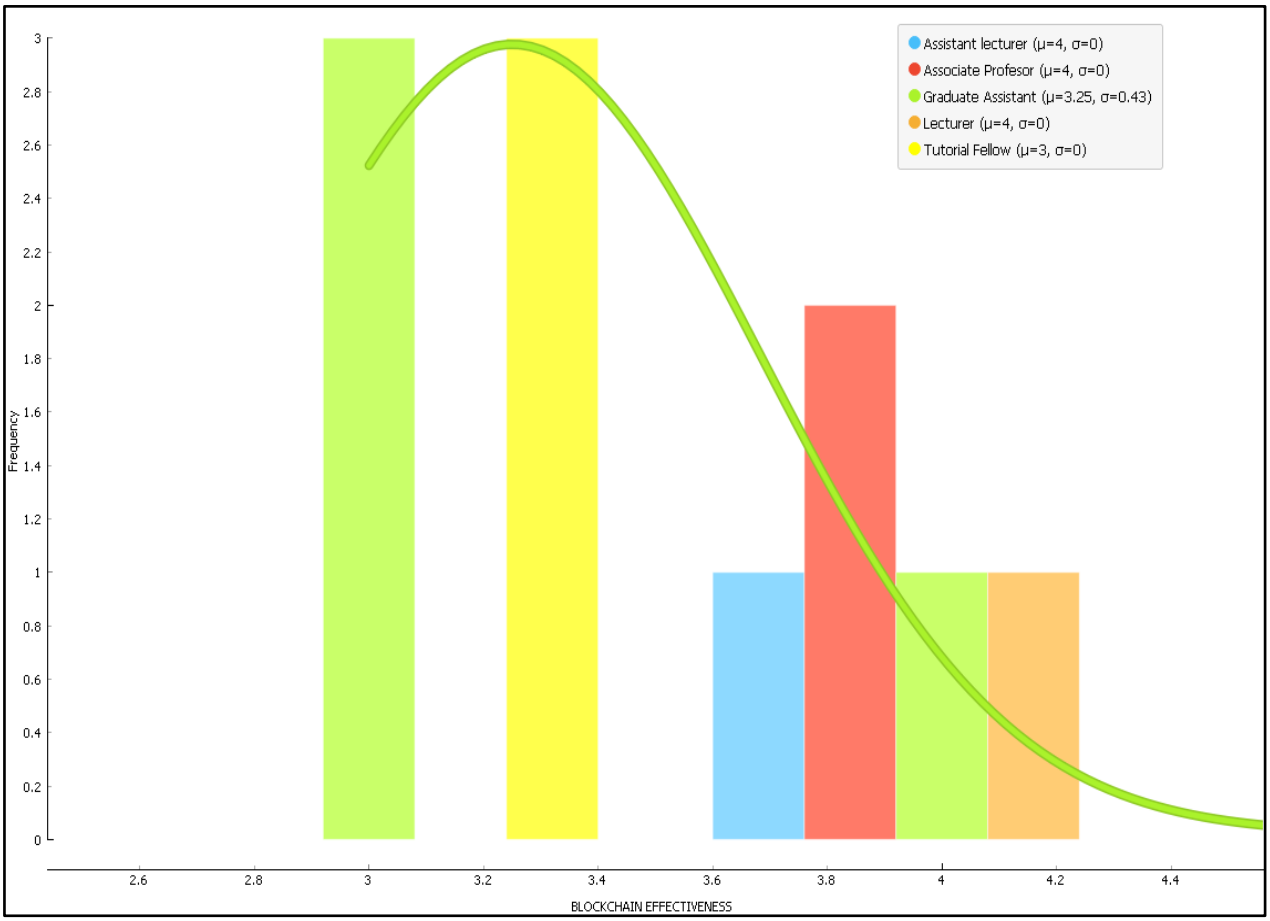

Figure 1: Blockchain Technology Acceptance

Most of the examination administrators (82%) agreed with adopting Blockchain technology to be embedded in the current system. Extract from the respondents P023 verbatim is as indicated hereunder;

"*I agree with the adoption of Blockchain technology since the current world is changing very fast, and academia should not lag with the current tech that has been invented*". [P023]

5.1 Blockchain technological framework to enhance integrity

In the adoption of the Blockchain technological framework to enhance the integrity of the result processing systems, the respondents were given the following categories: As shown in Table 2, Overall, 90.91% of the respondents agreed with the use of the Blockchain technological framework to enhance the integrity of the exam system while 9.09% disagreed about the adoption of Blockchain technological framework to enhance the integrity of the examination system.;

Table 2: Blockchain Framework to Enhance Integrity

Response	Percentage (%)	Number of Respondents
Agreed with the framework	90.91%	**192**
Disagreed with the framework	9.09%	**19**
Total	100%	211

On the various categories, Assistant Lecturers (μ=4, σ=0) and Lecturers (μ=4, σ=0) both have the highest mean score of 4, indicating a high level of acceptance of the usage or positive attitudes toward using Blockchain technology to enhance integrity. Associate Professors (μ=3.5, σ=0.50) have a moderately high mean score, suggesting a positive attitude but slightly lower than the Assistant Lecturers and lecturers. Graduate Assistants (μ=3.75, σ=1.09) and Tutorial Fellows (μ=3, σ=0.83) fall between the other groups. Graduate Assistants have a higher standard deviation, suggesting more variability in reported usage scores within this group compared to Tutorial Fellows.

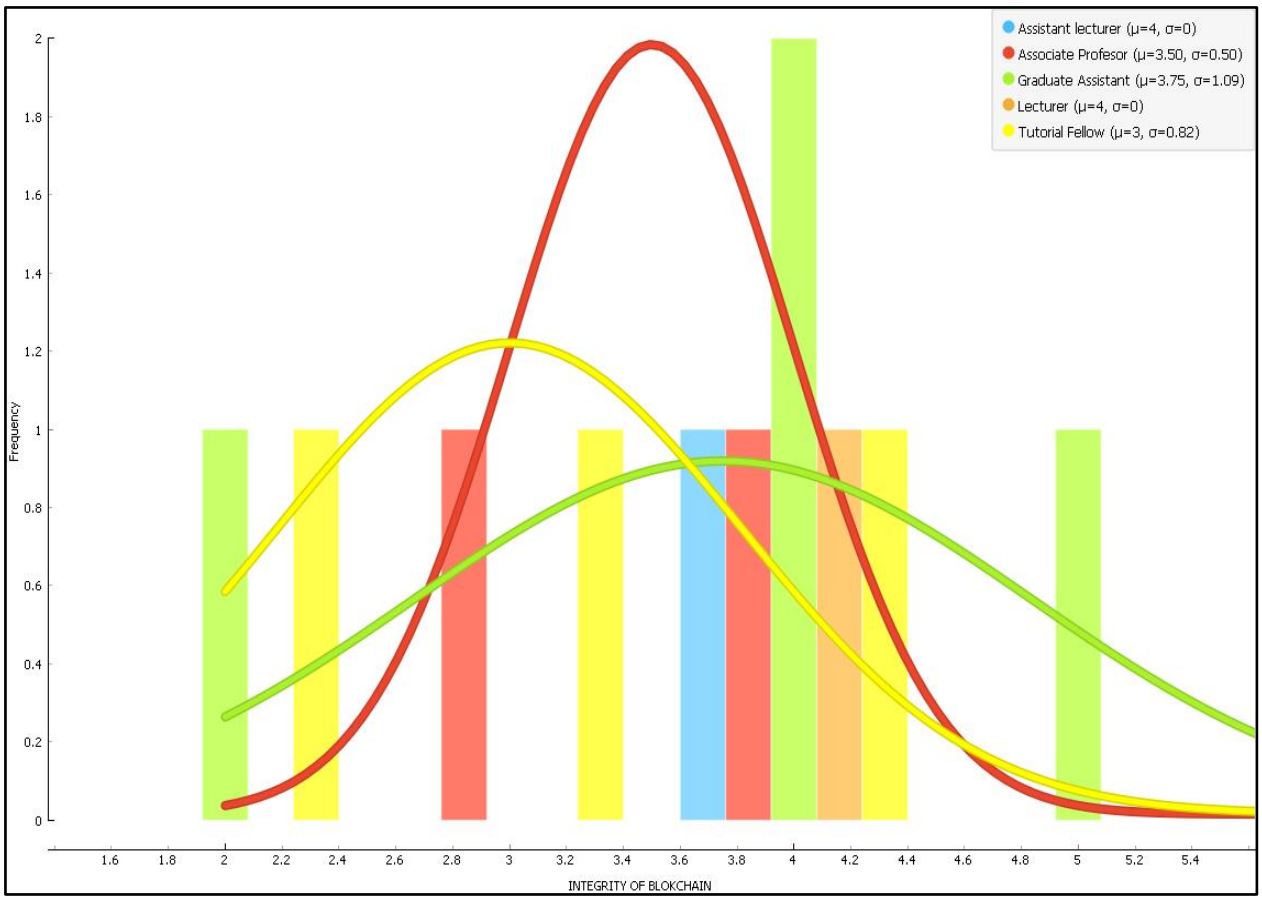

Figure 2: Blockchain Technology to Enhance Integrity Response

Most of the examination administrators (92%) were very positive about using the Blockchain technology framework to enhance the integrity of the current examination system. One to the respondence P056 extract response is hereunder;

"*I think Blockchain technological framework would be an excellent idea in enhancing integrity where every person has the right within the system to verify and validate the results that have been entered into the system, and in case a change has been done with one person, the rest get the notification Kind of tracking and monitoring the results in the system*". [P056]

Regarding the use of Blockchain technology to enhance the integrity of the examination system, an impressive 90.91% of respondents agree. P012 further underscores the potential of Blockchain technology to elevate the security level of the examination processing system. The use of "higher integrity level" implies an acknowledgement that the current system may have security gaps that can be addressed through the adoption of Blockchain.

A related study by (Baiod et al., 2021) on Blockchain applications across multiple domains, a survey done in Canada, also indicates that Blockchain technology can be used to increase trust among the users and data stored in the system. They further explain that the Blockchain mechanism's underlying decentralisation is a good design of Blockchain-embedded protocols and cryptography property to enforce trust

and ease its verification. These denote some positive uses of Blockchain technology in the examination system to enhance integrity. A related study by Khatter and DevanjaliRelan (2022) on non-functional requirements for Blockchain-enabled medical supply chains denoted that though Blockchain has transformed how the business operates, it is still considered a disruptive technology. They further indicate that scalability, non-repudiation, data privacy, and flexibility should be addressed early in implementing Blockchain infrastructure. These issues need to be dealt with specific techniques as the existing system development process does not integrate many aspects of this relatively new Blockchain technology. The respondents, though, in this study highlight the importance of transparency and validation within the system, with some noting the value of real-time tracking and monitoring. Integrating blockchain technology to bolster the examination system's integrity aligns with the proposed blockchain framework. The respondents' positive attitudes suggest a strong foundation for implementing Blockchain to safeguard the integrity of examination results, thereby making the proposed framework a viable and attractive option.

A related study (Smys & Wang, 2021) on enhancing smart vehicles by applying a Blockchain-based framework indicates that the framework simulation results indicate that the proposed work shows positive results to secure vehicular networks, vehicular forensics and trust management. 84.55% of respondents in this study agree that the Blockchain technological framework can enhance the examination result processing system security. These are also underscored by (Baiod et al., 2021) in their study on the application of Blockchain across multiple domains, which was a survey done in Canada that Blockchain technology can be used to enhance the security of a system through its robust cryptography that gives users ownership of addresses and the associated crypt assets in an assortment of public and private keys. This is also supported by Bucea-Manea-ţoniş et al. (2021), who, in their study on enhancing sustainable higher education through the use of Blockchain technology enhances sustainable higher education found decentralisation, security, and integrity can be provided by Blockchain, as well as anonymity and encryption.

In a more in-depth survey of respondents, Assistant Lecturers and Lecturers display the highest mean score of 4, indicating strong support for Blockchain in security enhancement. Associate Professors and Graduate Assistants also express positive attitudes, albeit with slightly lower mean scores. Tutorial Fellows demonstrate a slightly lower mean score but maintain a positive stance. Examination administrators are mainly in favour, with 80% agreeing that Blockchain technology can enhance system security. Respondents P079 echo the sentiment that implementing a Blockchain framework can significantly enhance the security of TUK's examination result processing system. P079 emphasises explicitly the reliability and effectiveness of Blockchain in bolstering the system's security posture.

"I think coming up with a Blockchain technology framework for the examination system will be the most reliable way of enhancing the security posture of this current system". [P079]

The term "reliable" by P079 underscores the confidence in Blockchain as a trustworthy solution. Respondents highlight the decentralised nature of Blockchain, which allows everyone to validate results and contributes to system resilience; since Blockchain has no central point of failure due to its decentralised network, it can withstand most security attacks (Judijanto & Gamaliel, 2024). Their recognition of Blockchain's potential to bolster system security indicates that the proposed framework can address the critical security concerns within TUK's examination result processing system. Baiod et al. (2021) Although Blockchain has a positive impact, they further explain that one of the challenges with this technology is the inadequate Blockchain expertise in many organisations which acts as a stumbling block for Blockchain growth and adoption by various companies or organisations.

Contrary to Alam et al.'s (2021) study, which focuses on a Blockchain framework for issuing and verifying academic certificates using a distributed ledger, it does not encompass the examination result processing required to certify students regarding their pass or fail status after their educational journey. In this study, most respondents supported adopting the Blockchain technological framework in the examination result processing system. They recognise its potential to enhance integrity, security, and overall efficiency within the system. The responses from examination administrators emphasise the importance of resilience and security in the ever-evolving landscape of technology.

5.2 Proposed Blockchain Examination Framework

The processing of examination results begins when the lecturers enter the marked results into the examination result processing system. Each student's exam results would be recorded as a transaction on the examination result processing and deleted without consensus from the network participants. This is because any attempt to modify past results would require changing all subsequent blocks, making it practically impossible. As shown in Figure 3 (lecturers in the network, especially during exam moderation), the nodes validate and verify transactions using consensus mechanisms as proof of work or proof of stake to ensure integrity, accuracy and security. This program for validating the transactions that have been made implements smart contracts to automate business logic, such as calculating final grades or detecting anomalies (changing marks that have been validated and added to the block in the Blockchain system). This means that smart contracts would only execute when predefined conditions are met, ensuring accuracy and reducing the potential for human error when validating the students' marks within the system. Students' examination records are cryptographically linked to their Blockchain records, where stakeholders can independently verify and audit the results without relying on a centralised authority, as shown in Figure 4. Therefore, any change in the result processing system with Blockchain as the underlying technology guiding the system's operations must undergo the verification or validation process, thereby enhancing the integrity of the results without central authority.

The diagram below shows the overall Blockchain Framework for the examination result processing system.

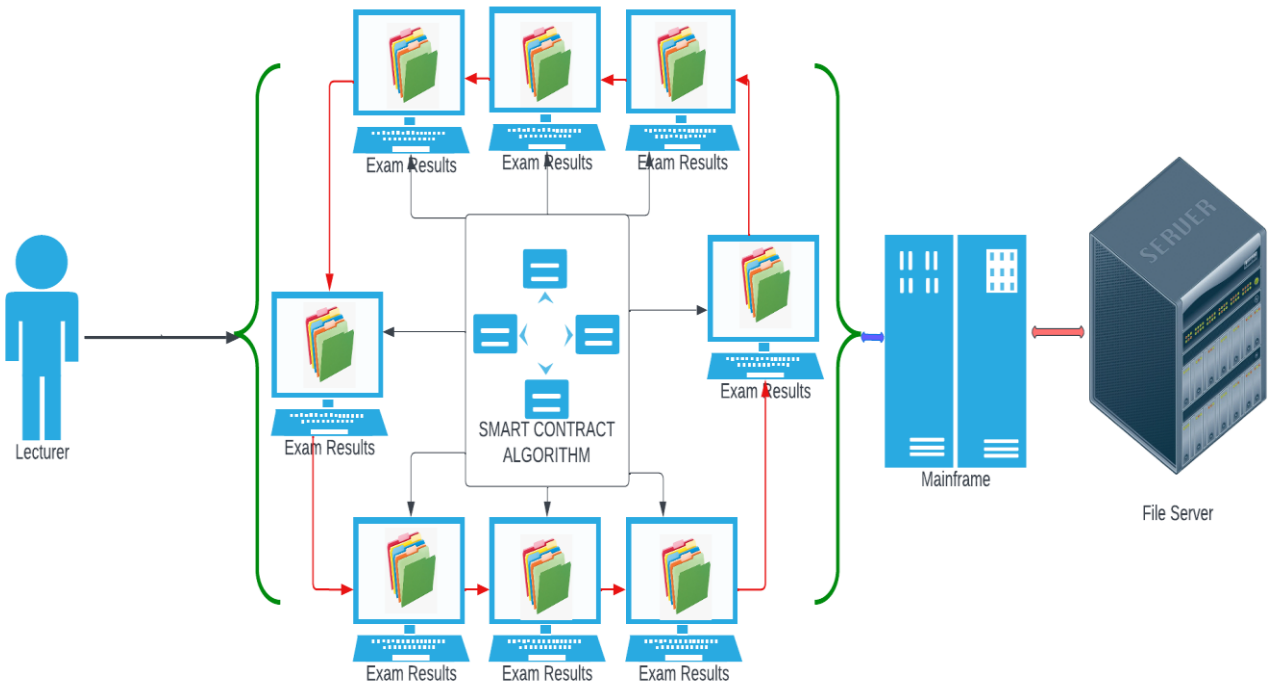

Figure 3:Blockchain Framework Diagram

The diagram below shows the verification and validation process of a single transaction initiated by a node (Lecturer) within the Blockchain system's network.

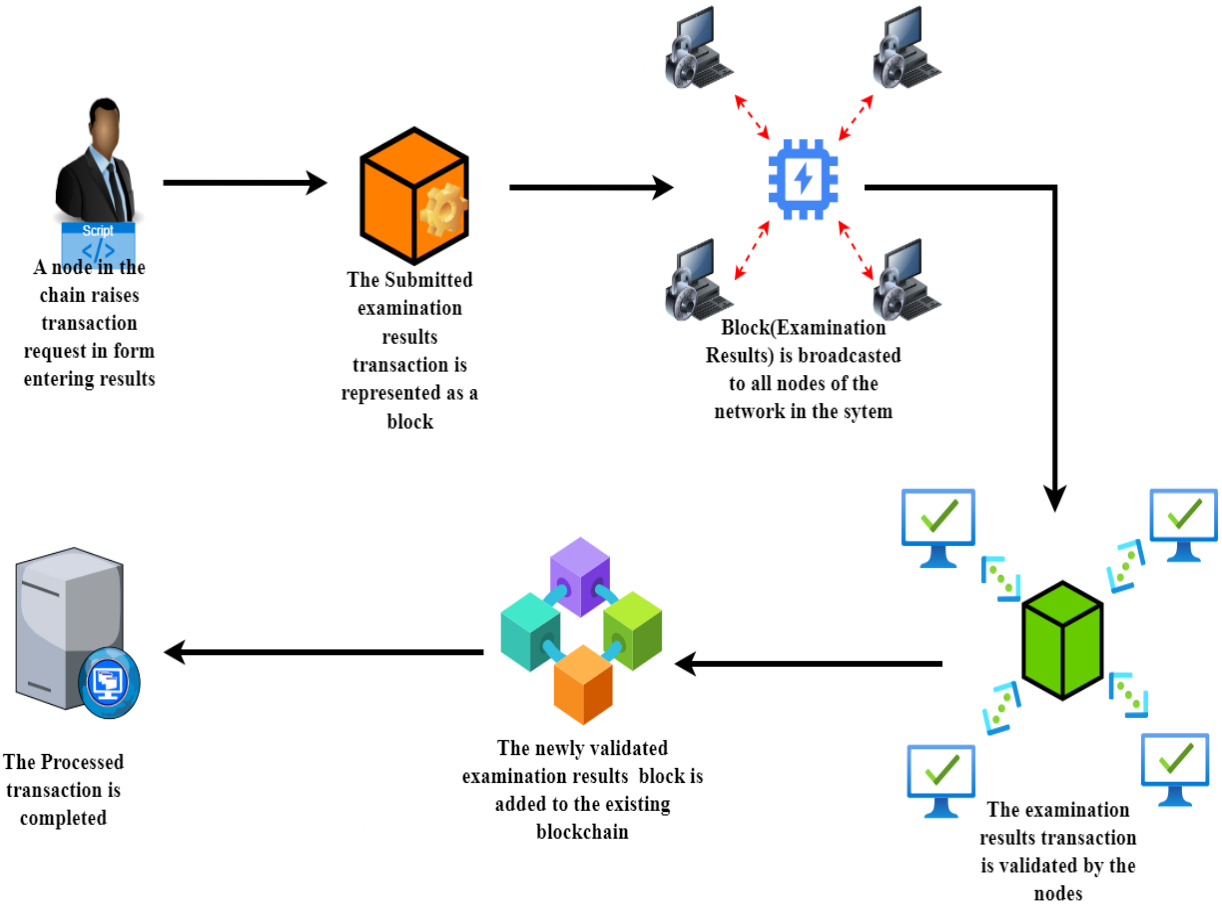

Figure 4: How transactions from the framework

Blockchain, therefore, can significantly enhance integrity and security in an examination result processing system. Carefully plan for the implementation, considering the specific needs of the educational institution for the examination processing system, and address potential challenges that might arise, like scalability and user adoption of the system. Applying the Blockchain Framework in the examination result processing system holds immense promise for educational institutions seeking to enhance their processes' integrity, security, and efficiency. By embracing this framework, institutions can create a transparent, tamper-proof, and automated system that benefits students, educators, and administrators alike. The resulting trust, accuracy, and streamlined operations have the potential to transform the educational landscape, empowering students and fostering a culture of innovation and excellence in education. As Blockchain technology matures, educational institutions will embrace its potential, leading to a more transparent, secure, and efficient future in result processing.

6. CONCLUSION

Analysing user needs assessment for an ideal examination result processing system emphasises the potential impact of integrating Blockchain technology to meet these needs. Respondents prioritise features such as a user-friendly interface, accurate result processing, real-time tracking and monitoring, secure user authentication, compatibility with other systems, reliable backup, and automated report generation. These requirements align with studies emphasising the importance of fairness, maintainability, transparency, security, and performance in user needs analysis. Blockchain's attributes, including data integrity, security, and transparency, resonate with these priorities, offering a transformative solution to enhance the system. Features like communication channels and data protection, although rated lower in importance, are not to be overlooked, and Blockchain's cryptographic security measures and decentralised data storage can address these aspects. The proposal to integrate Blockchain aligns with the Diffusion of Innovation Theory and Lewin's Model of Change Management, demonstrating a readiness for change and a commitment to meeting user expectations. Ultimately, Blockchain technology has the potential to create an ideal examination result processing system that satisfies both lecturers and administrators at TUK by enhancing transparency, data integrity, security, and efficiency.

7. RECOMMENDATIONS

This study can derive several actionable recommendations for Kenyan Universities looking to enhance the integrity and security of their result processing:

i. The integration of Blockchain technology into the examination result processing system for Kenyan Universities is based on the compelling insights derived from the user needs assessment analysis. The prioritised features identified by respondents, such as a user-friendly interface, accurate result processing, real-time tracking and monitoring, secure user authentication, compatibility with other systems, reliable backup, and automated report generation, align with the critical elements emphasised in various studies on user needs analysis. Blockchain's inherent attributes, including data integrity, security, and transparency, resonate perfectly with these priorities, and its integration promises to be a transformative solution that can significantly enhance the system's performance and user satisfaction. Even features rated lower in importance, such as communication channels and data protection, should not be underestimated, as Blockchain's cryptographic security measures and decentralised data storage can effectively address these aspects. Universities in Kenya should revise data protection and privacy policies to incorporate the advanced capabilities of Blockchain technology. This includes adapting regulations to support decentralised data storage and enhanced cryptographic security. The various universities in Kenya Institutions need to ensure that the integration of Blockchain complies with local and international standards for educational technology, which may require the development of new compliance frameworks. The successful implementation of Blockchain in examination processing will contribute to the broader understanding of how emerging technologies can be adopted in educational settings to improve trust and transparency in Kenyan universities. This recommendation enriches theories surrounding trust in digital systems, particularly in how Blockchain can mitigate concerns over data manipulation and fraud in academic institutions. Training faculty and administrators on Blockchain systems to ensure seamless integration and efficient use is crucial. Practical efforts should focus on integrating Blockchain with existing university systems in Kenya, followed by comprehensive testing to ensure reliability and functionality.

ii. Based on the compelling findings and strong consensus among respondents, integrating the Blockchain framework into our educational institution's examination result processing system is recommended. The unanimous support from Assistant Lecturers, Associate Professors, Lecturers, and examination administrators, coupled with the willingness of Graduate Assistants and Tutorial Fellows to embrace innovation, highlights the readiness of our academic community to harness this transformative technology. Particularly noteworthy is the substantial agreement among examination administrators on adopting Blockchain technology, which recognises the imperative of staying at the forefront of technological advancements in academia. Furthermore, the resounding support for Blockchain's potential to enhance the integrity of our examination system reflects a keen awareness of the security challenges in our current setup. By incorporating Blockchain, we can establish a transparent, tamper-proof, and automated system that benefits students, educators, and administrators alike. This move builds trust and accuracy and streamlines our operations, positioning our institution as a pioneer in leveraging technology to enhance education. As Blockchain technology evolves, our proactive approach to its adoption will lead us toward a future characterised by transparency, security, and operational excellence in result processing. Universities in Kenya should implement policies that encourage the adoption of innovative technologies by academic staff, such as offering grants or recognition to departments that lead in technological integration. New policies should be established to involve all relevant stakeholders in the education sector, including students, in discussions on technology adoption, ensuring comprehensive support and understanding in the various Kenyan universities. The introduction of Blockchain serves as a case study in change management within educational institutions, providing insights into how emerging technologies can be effectively adopted in the education sector in Kenya. The widespread agreement among academic staff underscores the importance of collaborative innovation, where multiple stakeholders actively contribute to and support adopting new technologies like Blockchain. A strategic approach to implementing Blockchain should be developed, including pilot projects in select departments to test the technology's effectiveness in the result p[processing systems in Kenyan Universities. Establishing regular assessment and feedback mechanisms is essential for monitoring the impact of

Blockchain integration and making necessary adjustments to optimise outcomes for processing the examination results.

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