

Blockchain-Enabled Conceptual Framework for Enhancing Academic Transcript Issuance and Authentication in the Nigerian Educational System

Akuma C. Fortune^{a*}, Etemi J. Garba^a, Mohammed Usman^a and Adaiti A. Kadams^a

^aDepartment of Computer Science, Faculty of Physical Sciences, Modibo Adama University, Yola, Nigeria.

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ABSTRACT

The issuing and authentication of academic transcripts are essential in the ever-changing landscape of educational systems since they serve as a means of validating an individual's academic achievements. However, difficulties in confirming these transcripts' authenticity exacerbated by manual procedures and paper-based system have raised questions about their legitimacy, especially in Nigeria. To address these urgent issues, this research presents a conceptual revolutionary blockchain-based framework for the Nigerian education system. The suggested solution will reduce dependency on issuing institutions and improve system efficiency by providing digital transcripts and automated authentication processes by utilizing blockchain's decentralized nature, transparency, and security features. The system will use blockchain-stored hash values for authentication and integrates on-chain revocation features to protect data integrity, reduce fraud risks, and enable quick and dependable authentication. By filling a vacuum in the literature, concentrating on issues unique to transcripts, and offering a contextually appropriate solution that has the potential to completely transform the Nigerian academic transcript issuance and authentication process, this work advances our collective understanding.

1. Introduction

Academic transcripts are official documents issued by educational institutions to certify an individual's academic accomplishments and learning achievements. These documents are given to students who have fulfilled graduation requirements and provide a comprehensive list of courses taken and the cumulative grade point average earned by the student. Academic transcripts serve as an authoritative document used to determine the class of a graduate's certificate and are highly valued as they serve as proof of an individual's human capital development, which includes knowledge, talent, capabilities, and aptitudes acquired through formal or informal education. This document is significant in the workplace as it not only demonstrates the bearer's level of knowledge, competence, and skills, but also shows their abilities, reliability, strengths, and dedication (Rahman *et al.*, 2023).

In Nigeria, academic transcripts are deemed authentic if the issuing institutions have been legally sanctioned to operate as certification-granting entities. However, due to technological advancements, the production and distribution of counterfeit academic transcripts has become more accessible, with improved quality, making it increasingly difficult to differentiate between genuine and fraudulent documents (Obilikwu *et al.*, 2019). When falsified transcripts are issued under the name of educational institutions, their reputations and brand identities are negatively impacted. In this context, authentication refers to the process of confirming the authenticity, accuracy, or legitimacy of an official academic transcript. It helps to establish whether someone or something rightfully and legally belongs to an organization, an individual, or both.

The authenticity of academic transcripts in Nigeria is frequently called into question due to the way they are issued and verified. This lack of trust is caused by the inability of schools and businesses to quickly verify the academic transcripts that have been acquired. Although there are some online transcript generation and issuance systems in Nigeria that improve the speed, quality of service, and reduce costs for certificate authentication, the regular computerized system is vulnerable to attacks and makes it easier for certificate forgery and racketeering, especially with the current advanced software technology.

In contrast to the current manual and online process, which requires university intervention to confirm the

* Corresponding author. Tel.: +234 906 878 6588

E-mail address: chijiukafortune@mau.edu.ng (Akuma C. F.)

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legitimacy and validate the contents of transcripts and verify essential details, the use of digital systems like blockchain technology offers the advantage of swift and secure academic authentication while maintaining the institutional integrity of academic transcripts. This allows institutions to receive the charges applied to transcript requests without any hassle.

Blockchain technology is a digital ledger that records transactions. It is comprised of multiple blocks of data, where each block contains individual transactional data that is interlinked in a sequence called the "chain." Blockchain technology allows for secure digital transactions, much like how the Internet facilitates the sharing of information (Roopika, 2020). According to Maheswari's (2020) explanation, Blockchain presents a well-organized data structure comprised of blocks that include transactions. In this framework, each block is intimately linked to the one preceding it in the chain. The first block in this sequence is referred to as the Genesis block, while subsequent blocks are methodically piled on top of one another, resulting in the creation of a blockchain stack.

Blockchain technology is superior to current technologies because it combines a number of important features, such as decentralization, distribution, security, transparency, and speed. It operates as a linked list data structure and maintains complete records of data and transactions via a peer-to-peer network that is open to the public. The SHA-256 hashing algorithm is used to protect data movements, and transaction summaries are combined into unchangeable blocks of data. The integrity of recorded transactions throughout the network is guaranteed by a tamper-proof chain that is created by sequentially connecting these blocks using hash values. Blockchain technology protects data security by using cryptography to stop certificate falsification and unauthorized access. The use of blockchain technology for credential authentication highlights how stable and dependable it is. Furthermore, with ideas like the universal ledger, smart contracts, and cross-chain, blockchain creates operational frameworks and consensus processes (Kumutha and Jayalakshmi, 2018).

According to Kareem and Shakir (2023), each block in a blockchain serves the principal purpose of recording, validating, and spreading transactions to other linked blocks. Any modification or elimination of a block inside the chain would subsequently affect blocks beyond it.

Falsified academic credentials, such as transcripts and certificates, are becoming more common in Nigeria. Notable people, like the former director general of the Federal Institute of Industrial Research, have been accused of falsifying their diplomas. The severity of the problem has been brought to light by recent events, such as the case of Mr. Chima Igwe, who allegedly falsified his academic credentials by claiming to have a PhD from the Université d'Abomey-Calavi in the Benin Republic. Similarly, it was found that Peter Ekemezie, a senior lecturer at Nnamdi Azikiwe University, had plagiarized his PhD and had a phony Master's degree. Not only do these incidents compromise the credibility of educational establishments, they also cost the government and people money and prevent worthy applicants from advancing in their careers (Ojo, 2020).

Furthermore, students in Nigeria experience major delays and stress due to the difficult procedure of obtaining academic transcripts. Elvis Izeke's battle to obtain his transcript from the University of Benin for scholarship applications serves as an example of this difficulty. For Izeke and many others, administrative inefficiencies and bureaucratic roadblocks resulted in protracted delays and lost chances (Ayetoto-Oladehinde, 2019). There are still issues with the procedure, such as students having to make repeated payments and experiencing administrative bottlenecks, even with attempts to digitize it, such as the Electronic Transcripts and Documents Exchange in Nigeria (ETX-NG). To ease the process of obtaining transcripts and lessen the load on students navigating the Nigerian educational system, immediate reform is required.

In order to improve the process' efficiency, security, and transparency and to enable awarding institutions to get the required fees for the transcript issuance and authentication service, a conceptual blockchain-based system framework for academic transcript issuance and authentication in Nigeria is being proposed.

2. Literature Review

Blockchain technology was developed earlier than Bitcoin, which was first introduced by Satoshi Nakamoto. But it was Bitcoin that brought blockchain technology to the public's attention by demonstrating its promise with decentralized, block-based systems that are resistant to censorship. Although some people mistakenly believe that Bitcoin and blockchain are the same thing, it's important to understand that blockchain technology was used in the development of Bitcoin. The quick rise in popularity of blockchain can be ascribed to its intrinsic benefits, which have propelled it to the forefront of international technical advancements. As a result, a great deal of scholarly

research has been done to investigate its many uses, one of which is the protection of academic document integrity.

Said *et al.* (2023) identified major problems with the current authentication system, such as manual processes, unverifiable credentials, and centralized storage vulnerabilities, in order to solve the widespread problem of fake educational certificates in Tanzania. In order to improve certificate authentication, their study suggested a blockchain-based conceptual model that included smart contracts and the Interplanetary File System (IPFS). The authors showcased the ability of their model to address the mentioned shortcomings by utilizing the qualities of blockchain, which include transparency, security, and immutability. This would increase the credibility of educational qualifications and successfully combat fraudulent practices.

The problems with centralized certificate issuing and authentication system were emphasized by Bokariya and Motwani (2021), who emphasized the lack of anti-tampering procedures as a vulnerability to hacking, data loss, and forgery. In an effort to improve security and expedite the authentication process, they suggested a decentralized certificate authentication system that makes use of blockchain technology. Their system aims to tackle problems associated with certificate counterfeiting, speed up certificate authentication, and streamline the issuance process by integrating blockchain's cryptographic connectivity and decentralization features into a Distributed Application (DAPP). This provides a strong response to the present challenges in Certificate Issuance, Authentication, and Validation.

In the current digital era, Priyadarshini *et al.* (2023) discussed the difficulties in preserving and confirming digital academic credentials. They put out a plan to improve certificate security and expedite the authentication procedure by utilizing blockchain technology. Their solution converts paper certificates into sophisticated digital certificates and uses cryptographic algorithms to generate hash code values. These certificates are then safely stored on the blockchain. Additionally, they released a mobile certificate authentication application, giving businesses and institutions a quick and easy way to confirm academic certificates.

There is a major gap in the development of comprehensive systems for academic transcript issuance and authentication, especially in the Nigerian setting, as the majority of the literature now in publication concentrates on blockchain-based certificate authentication. The difficulties unique to transcript procedures such as digital application, institutional payments, and smooth contacts between students and verifying institutions are ignored in the current studies by Said *et al.*, (2023), Bokariya and Motwani (2021), and Priyadarshini *et al.*, (2023). By tokenizing student transcripts on the blockchain, expediting payment procedures, and removing delays, our suggested conceptual framework fills in these gaps and allows Nigerian graduates to receive prompt authentication.

3. Materials and Method

Our suggested solution makes it simple to determine whether an academic record (transcript) is authentic or not. It entails using smart technologies like IPFS and blockchain to verify the integrity and uniqueness of the record. Every transaction is recorded as a block of data as it happens. Every block is connected to the ones that came before and after it. The following technologies and tools were employed in this study:

Blockchain networks: These include Ethereum, Solana, Avalanche, and others. They offer a clever settlement feature. Blockchain network offers decentralized public ledgers for the purpose of confirming and recording transactions. Users' certain fees for the transactions they perform on the blockchain network. The fees are referred to as "gas" since they vary according to the amount of processing power used.

Smart contracts: Smart contracts are small pieces of code that operate on a blockchain when a user performs certain tasks. These are actual apps that operate as long as certain conditions are satisfied. Reliable agreements and transactions can be carried out amongst disparate, anonymous events via smart contracts, negating the need for a central authority. Solidity can be used to construct these smart contracts. An object-oriented programming language for creating intelligent contracts is called Solidity. Solidity is notably enhanced by JavaScript, Python, and C++ (Chaudhari *et al.*, 2023).

Decentralized Applications: Decentralized Applications, or DAPPs, are computer applications that operate decentralized, or without a single central server, on a peer-to-peer (P2P) network of computers or a blockchain. DApps take advantage of the decentralized characteristics of blockchain technology, in contrast to conventional centralized programs.

The DApp acts as a middleman in communications between users, IPFS, and the blockchain. Smart contracts running on the blockchain power the DApp.

Interplanetary File System (IPFS): IPFS is a distributed file system that operates on a peer-to-peer basis. Its goal

is to establish a decentralized, efficient, and worldwide network for file sharing and saving. IPFS employs a content-based addressing approach, in contrast to conventional centralized systems, in which files are recognized by their content rather than by their location. Based on the content of each file, IPFS assigns a unique Content Identifier (CID). The data in the file is cryptographically hashed using this CID (Chaudhari *et al.*, 2023).

The study's main goal is to create a blockchain-based conceptual model for academic transcript issuance and authentication. It examines the current authentication method for transcript issuance, the problems with the current system that have led to academic certificate and transcript racketeering, and how to use blockchain to close these gaps in the current system. The schematic representation of the current system, the proposed system, and the individual modules that comprise the proposed blockchain mode are presented below.

3.1 Existing System

In Nigeria, the current procedure for obtaining an academic transcript is for a graduate to visit the university, pay, and send a formal request letter to the registrar that includes the address of the recipient institution. The transcript is assembled by the exams and records unit and sent securely by courier to the requested institution when it has been approved (as shown in Figure 1). Although this approach guarantees the security, accountability, and integrity of the academic record, it might cause lengthy delays often requiring two months or longer which may encourage graduates to use falsification as a last choice in times of need.

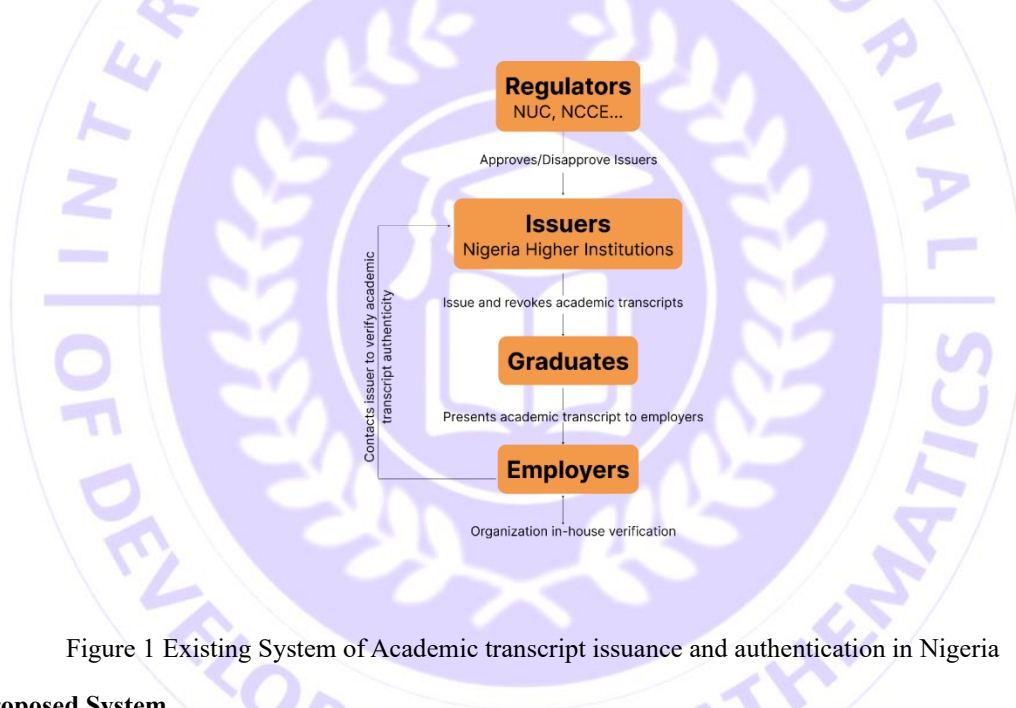


Figure 1 Existing System of Academic transcript issuance and authentication in Nigeria

3.2 Proposed System

Using blockchain technology, the suggested architecture improves academic transcript issuance and authentication, focusing on transcripts pertinent to recruiting from secondary to university levels. Conventional parties are still involved, including recruiters, graduates, issuing institutions, regulatory authorities, and a central authority. Decentralized applications (DAPPs) interfaced with the Interplanetary File System (IPFS) and the blockchain facilitate user interaction. Transcript data and related metadata are managed by smart contracts running on platforms such as Ethereum, Solana, Avalanche etc., while decentralized off-chain storage is offered by IPFS to maximize system efficiency. Figure 2 shows the schematic representation of the proposed model based on blockchain, smart contracts, IPFS, and a decentralized application.

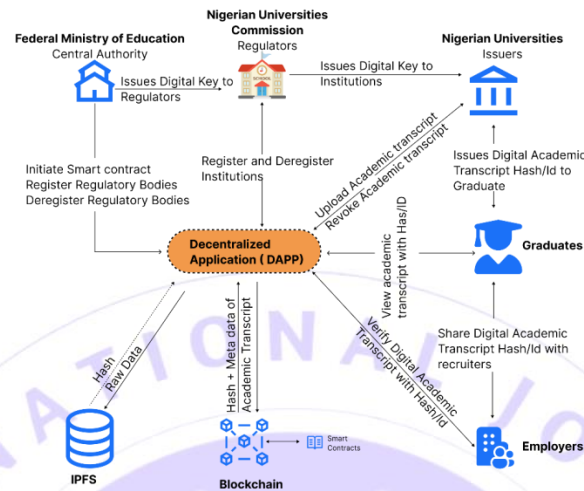


Figure 2 Schematic representation of the proposed blockchain based academic transcript issuance and authentication system

3.3 Management of User Roles and Permissions

By using smart contracts to control user responsibilities and permissions, the architecture makes sure that academic transcripts are only issued or revoked on the blockchain by approved institutions. This structure, which consists of a central authority, regulators, and issuers in a hierarchy, permits government monitoring. The suggested model's hierarchical role structure, which includes the central authority, regulators, and issuers, is seen in Figure 3. Despite having access to ledger data, recruiters and grads do not conduct transactions using this system. The smart contracts, which register issuers and regulators, are started and managed by the central authority (Federal Ministry of Education). It is possible for several authorities to onboard institutions, keep an eye on compliance, and enforce rules including the suspension of institutions. User data is managed by smart contracts, which store the pertinent information on the blockchain and raw issuer files on IPFS that can be accessed by Content IDs (CIDs) for authentication.

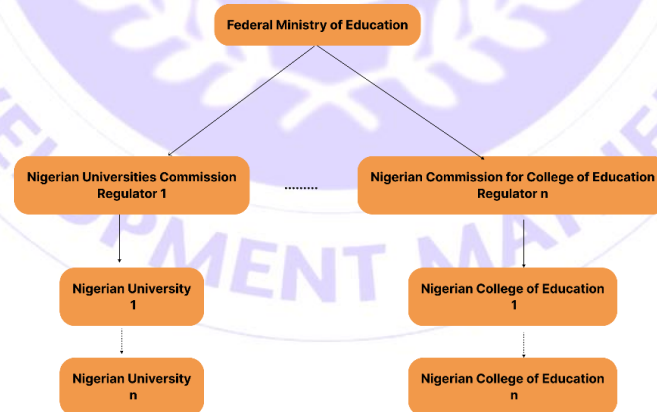


Figure 3 Management and authorization scheme in the proposed system

3.3.1 The Issuance Procedure

Issuers produce digital transcripts with important academic information, frequently in PDF format (According to Figure 4). These files are uploaded to the DApp along with metadata, such as the graduate's blockchain address.

After that, the DApp sends them to IPFS for hashing, resulting in a distinct hash value. A smart contract verified by the issuer's private key stores this hash and other metadata on the blockchain.

Graduates maintain their blockchain addresses through digital wallets such as Trust or Phantom in order to access their transcript via the DApp. Smart contract mapping ensures that every transcript on the blockchain corresponds to the appropriate graduate. However, in order to examine their transcript, graduates must pay a gas price that is determined by the issuer.

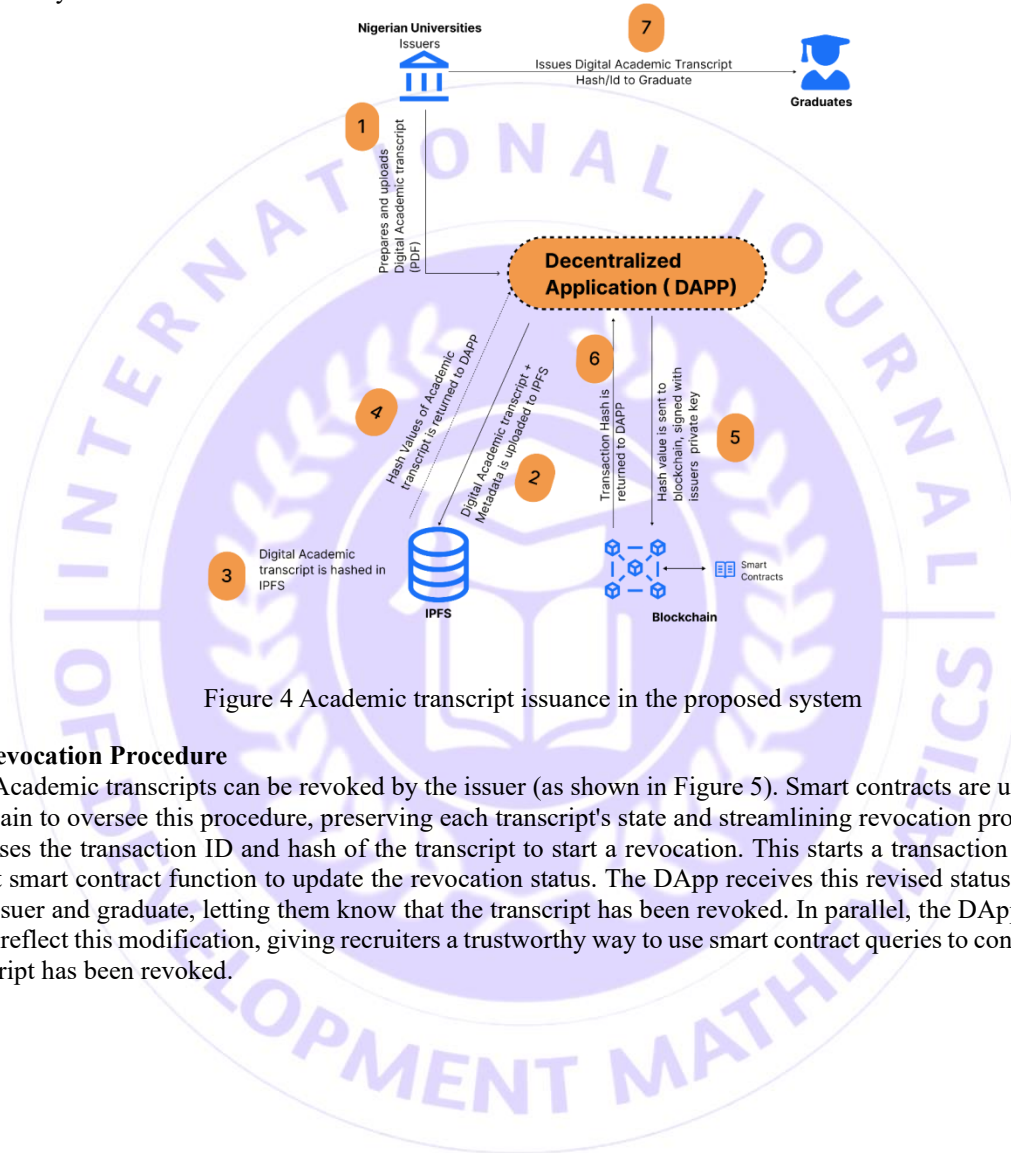


Figure 4 Academic transcript issuance in the proposed system

3.3.2 Revocation Procedure

Academic transcripts can be revoked by the issuer (as shown in Figure 5). Smart contracts are utilized by the blockchain to oversee this procedure, preserving each transcript's state and streamlining revocation procedures. The issuer uses the transaction ID and hash of the transcript to start a revocation. This starts a transaction that uses the relevant smart contract function to update the revocation status. The DApp receives this revised status and relays it to the issuer and graduate, letting them know that the transcript has been revoked. In parallel, the DApp updates the IPFS to reflect this modification, giving recruiters a trustworthy way to use smart contract queries to confirm whether a transcript has been revoked.

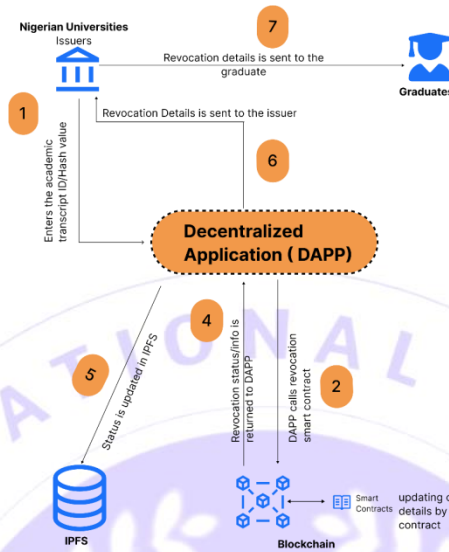


Figure 5 Academic transcript revocation procedure in the proposed system

3.3.3 Procedure for Authentication

As shown in Figure 6, graduating students use their academic transcripts to apply for jobs and admittance to other schools, among other chances. Graduates give recruiters their hash, or unique identity, to verify these transcripts; this is usually done through secure channels like email or applications specifically designed for that purpose. The payment and authentication process are then started when recruiters enter this identifier into the DApp's authentication interface. The DApp initiates the relevant smart contract function for transcript authentication upon payment confirmation. It does this by searching the blockchain ledger for the designated hash and obtaining the transcript's information. For thorough validation, the DApp concurrently retrieves related transcript files, issuer profiles, and metadata from the IPFS. The DApp performs thorough authentication checks and provides recruiters with the results, along with the raw transcript and issuer data for download and perusal if needed. Graduates receive the authentication result via a separate communication channel after validation. Through the authentication of the transcript's origin, content integrity, issuer validity, revocation status, and holder identity, this method guarantees recruiters that the transcript is authentic.

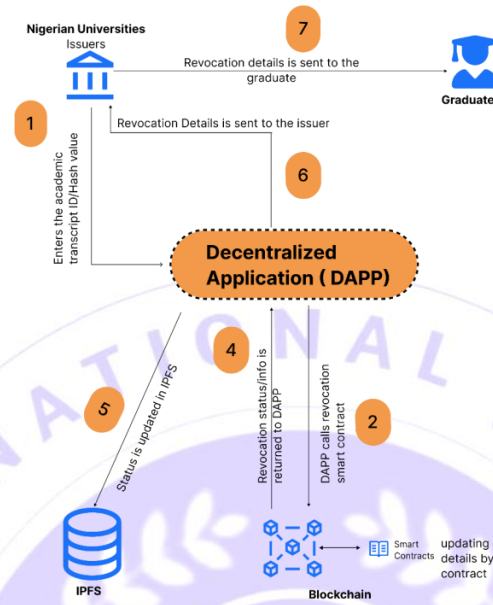


Figure 6 Academic transcript authentication procedure in the proposed system

4. Result and Discussions

There are issues with Nigeria's present academic transcript authentication system because manual procedures and paper-based transcripts are involved. In order to increase productivity, our proposed blockchain technology solution will digitize these records by automating the issuing and authentication processes. This change increases revenue for educational institutions by allowing them to charge for processing and authentication of transcripts. Currently, recruiters struggle with expensive and time-consuming authentication processes. They may quickly conduct searches using our blockchain system and get trustworthy, instantaneous authentication results. Blockchain's digital hash values, as opposed to conventional paper transcripts, offer unambiguous evidence of validity, making authentication easier. Conventional solutions have higher costs and delays because they rely too much on issuers for authentication. By removing this reliance, recruiters may now independently authenticate statements and certificates, which speeds up the hiring process and lowers expenses. Recruiters may efficiently verify numerous papers by using our proposed system, which centralizes academic transcript issuance onto a single platform. This method reduces the dangers of fraud and document tampering and guarantees data integrity thanks to blockchain's strong security and transparency. Furthermore, our solution incorporates a revocation status into smart contracts so that issuers can cancel transcripts and notify recruiters in order to stop invalidated documents from being misused. With an emphasis on academic transcript issuing and authentication in Nigeria, this study contributes to the conversation on the potential applications of blockchain technology in educational systems. By addressing the shortcomings of fragmented and paper-based systems, the research presents a conceptual blockchain solution. In keeping with the global trends of digitization, the research proposes a switch to digital transcripts and automated authentications. By utilizing the disintermediation offered by blockchain technology, the solution will reduce reliance on issuers and streamlines procedures by enabling recruiters to perform autonomous authentication. Blockchain-anchored authentication and on-chain features provide enhanced security by strengthening against fraud and manipulation. The single platform that is being suggested expedites the authentication process by quickly supporting numerous certificates. Furthermore, the proposed framework provides valuable perspectives for improving regulatory frameworks in Nigeria's educational credentialing, with a focus on enhancing integrity, efficiency, and transparency.

Table 1: Identified academic transcript issuance and authentication challenges and their proposed blockchain based

Solutions

Identified Academic transcript issuance and authentication challenges	Proposed Blockchain-Based Solutions
Dependence on paper-based academic transcripts and manual authentication in Nigeria	Introduction of digital academic transcripts coupled with automated authentication. Recruiters can authenticate by querying the transcript's hash on the blockchain, facilitating instantaneous results.
Fragmented issuance and authentication mechanisms	Deployment of an integrated platform for certificate issuance across various educational tiers, complemented by a unified interface for recruiters' authentication processes.
Reliance on issuers for academic transcript authentication	Harnessing the blockchain's disintermediation feature to enable recruiters to autonomously authenticate academic transcripts without necessitating engagement with issuers or regulatory bodies.
Inherent challenges in verifying current paper-based academic transcripts	Adoption of blockchain-stored hash values as authentication benchmarks, streamlining authentication through uncomplicated blockchain searches.
Communication impediments among involved parties	Dispensing with the need for inter-party communication by empowering recruiters to autonomously verify certificates via blockchain hash queries.
Susceptibility of centralized academic transcript record systems	Exploitation of blockchain's decentralized architecture and data replication across P2P network nodes to bolster resistance against cyberattacks and data breaches. The immutable nature of blockchain further fortifies security against potential internal tampering.
Challenges associated with academic transcript corrections and revocations	Integration of on-chain correction and revocation functionalities through smart contracts on the blockchain. This feature introduces a revocation status that reflects a certificate's validity, enabling recruiters to ascertain its authenticity.

5. Conclusion

The problems with academic transcript issuing and authentication in Nigeria are addressed in this research with a proposed blockchain-based system that addresses centralized vulnerabilities, inefficiencies in communication, and unverifiability. The suggested solution provides an effective, reliable, and scalable method for academic credential authentication by automating authentication, improving authenticity with blockchain-stored hash values and revocation statuses, and guaranteeing universal accessibility.

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