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Development of a Blockchain System for Licensing Services for Nigerian Communications Commission

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Abstract:- Digital assets face threats like unauthorized duplication, breaching intellectual property rights. Software licensing safeguards developers' rights and users' interests. However, traditional methods encounter challenges such as fraud, piracy, and lack of transparency. This study aims to enhance licensing using blockchain. Blockchain's decentralized system ensures encrypted, secure, and transparent transactions, potentially improving efficiency and security. The research proposes a novel approach using the Nigerian Communications Commission (NCC) as a case study, comprising token-based, hash-based, and smart contracts-based licensing. NCC issues certificates for Telecom services, with each license identified by numbers. Smart contracts automate the licensing process, enforcing terms and conditions. The study examines blockchain's benefits and challenges, including decentralization and trust. It contributes to software license management by leveraging blockchain's advantages.

Keywords:- *Blockchain; Smart Contract, Software Licensing, Intellectual Property, Wallet ID, Cryptocurrency.*

I. INTRODUCTION

The Nigerian Communications Commission (NCC) occupies a pivotal role in shaping the trajectory of Nigeria's telecommunications sector, serving as a beacon of technological innovation and regulatory oversight. In the ever-evolving landscape of the industry, the NCC remains steadfast in its commitment to refining licensing services, aiming for heightened efficiency, transparency, and security. Enter the Blockchain System for Licensing Services—a ground-breaking initiative poised to revolutionize the NCC's licensing operations.

Traditional licensing frameworks often grapple with inefficiencies stemming from bureaucratic processes, opacity in procedures, and vulnerabilities to fraudulent activities. However, blockchain technology offers a compelling antidote to these challenges by introducing a decentralized network that seamlessly verifies, issues, and manages licenses. Our research endeavours to elucidate the intricacies of implementing such a blockchain system within the NCC, shedding light on its functionalities, security protocols, and potential impact on Nigeria's telecommunications landscape.

With its immutable ledger and decentralized architecture, blockchain technology presents an ideal solution for navigating the complexities of licensing in a digitally driven environment. By harnessing blockchain, the NCC stands to streamline its operations, alleviate administrative burdens, and establish a transparent and secure framework for managing licenses. This transformative system not only empowers the commission but also benefits licensees and end-users alike, fostering trust and efficiency throughout the telecommunications ecosystem.

This paper undertakes a comprehensive exploration of the implications of implementing a blockchain-based licensing system within the NCC. We delve into the prevailing challenges confronting the commission in licensing management and elucidate how blockchain technology can effectively address these issues. Ultimately, our research contributes to Nigeria's broader digital transformation agenda by offering insights into the potential of blockchain to redefine regulatory compliance, operational efficacy, and stakeholder engagement within the telecommunications sector.

Blockchain, depicted in Figure 1, ensures trust and transparency in transactions. Its prominence, linked to cryptocurrencies like Bitcoin, Ripple, and Ethereum [1]. Its systematic implementation and proper policies offer significant promises [2]. However, organizations and governments face challenges in information reconciliation and security [3]. Blockchain addresses these by decentralizing system controls, fostering robust technical foundations for collaborative business processes. Governments ensure public trust in information and systems, supported by blockchain's trust and security, forming platforms for network building and ecosystem development.

Blockchain safeguards digital assets, notably in music, championing decentralized DRM systems [4]. In complex legal landscapes like Nigeria's music industry, blockchain offers promise [5], shifting DRM's focus from IP protection to accommodating stakeholders' needs, fostering decentralized systems. One solution proposes blockchain-based software licensing with IPFS for storage and smart contracts for validation [6], combating piracy with secure, scalable licensing validation. Blockchain and smart contracts promise transparent digital rights management and copyright licensing [7].

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Software piracy, exceeding USD 46.3 billion in 2018, prompts the need for innovative solutions [8]. Blockchain disrupts cooperation norms, offering efficient digital asset management via smart contracts [9]. Though transparency risks fraud, blockchain's immutability enhances transaction reliability [9]. Since Bitcoin's 2008 inception, blockchain gains traction for business security [10]. Nigerian firms embrace blockchain, advocating unified standards for equitable benefits [11]. Blockchain licensing ensures decentralization, security, and transparency for licenses, minimizing fraud and fostering trust through cryptography. Transparent records enable user audits, while smart contracts automate issuance and renewal, enhancing efficiency.

A. Benefits and challenges of Blockchain Licensing

Blockchain licensing offers advantages like decentralization, trust, transparency, smart contracts, and innovation [12]. Decentralization ensures licenses are stored on a blockchain network, minimizing fraud. Trust is established through cryptography, ensuring license authenticity. Transparency is facilitated by public records, enhancing accountability. Smart contracts automate processes like issuance and renewal. However, challenges like scalability, regulation, and adoption exist [13]. Scalability issues may affect speed and performance as transactions increase.

B. Problem Statement

This research endeavours to modernize the licensing process through the integration of blockchain technology, aiming to replace the traditional paper-based procedures prevalent in NCC licensing. Historically, NCC licensing involved manual tasks such as form filling, document submission, and file uploading for licenses like Short Code, International Data Access, Internet Service Provider, Private Network Link, among others, as depicted in Figure 1, the NCC License application form. Beyond NCC, numerous organizations encounter challenges with digital asset licensing, prompting an examination of some of these issues within this study.

In this article, the author advocates for a smart contract-based licensing approach, harnessing the advantages of blockchain technology to address issues surrounding copyright violations and unlicensed digital assets.

II. RELATED WORKS

Blockchain technology has gained widespread recognition across diverse industries due to its capacity to transform traditional processes, bolster security measures, and promote transparency. Within governmental agencies and regulatory bodies, the adoption of blockchain holds tremendous potential for optimizing operational efficiency and fostering greater accountability. Recognizing the need for enhanced efficiency and security within the telecommunications sector, the Nigerian Communications Commission (NCC) has embraced the potential of blockchain technology to modernize its licensing services. The literature surrounding blockchain applications in regulatory frameworks indicates a growing interest in leveraging this technology to improve transparency and accountability. Specifically, within telecommunications regulatory bodies such as the NCC, blockchain emerges as a compelling solution to tackle existing challenges and streamline licensing processes.

Blockchain technology has garnered significant attention across various industries for its potential to revolutionize traditional processes, enhance security, and foster transparency. Within the realm of government services and regulatory bodies, the adoption of blockchain holds immense promise for optimizing operations and ensuring accountability. In the pursuit of a more efficient and secure telecommunications sector, the Nigerian Communications Commission (NCC) has recognized the potential of blockchain technology in revolutionizing its licensing services. The literature on blockchain applications within regulatory frameworks suggests a growing interest in this technology's ability to enhance transparency and accountability. In the context of licensing services, particularly within telecommunications regulatory bodies like the Nigerian Communications Commission (NCC), blockchain presents a compelling solution to address existing challenges and streamline processes.

A. Blockchain Fundamentals and Regulatory Applications

The foundational work of Nakamoto [14] laid the groundwork for blockchain technology, introducing it as a decentralized ledger system with implications extending beyond cryptocurrencies. Building upon Nakamoto's pioneering efforts, Swan [15] further explored blockchain's capabilities, particularly emphasizing its potential for facilitating "smart contracts" and automating compliance processes, a feature that holds significant promise for licensing services. Numerous scholarly investigations have delved into the application of blockchain technology within governmental and regulatory frameworks, shedding light on its transformative potential. For example, Gupta et al. [16] underscored blockchain's capacity to enhance transparency, accountability, and operational efficiency in government services, underscoring its pivotal role in fostering trust among stakeholders. Similarly, Wang et al. [17] contributed to this discourse by examining blockchain's utility in regulatory compliance, demonstrating its efficacy in ensuring regulatory adherence and risk mitigation.

B. Blockchain in Telecommunications

Tapscott and Tapscott [18] discussed the transformative role of blockchain in telecommunications, emphasizing its capacity to streamline operations and reduce fraud. This is supported by recent studies like Mearian [19] who noted blockchain's role in improving the integrity of communication networks. Within the telecommunications sector, the integration of blockchain into licensing services has gained traction as regulatory bodies seek to modernize operations and address longstanding challenges.

C. Blockchain in Licensing Systems

Olnes et al. [20] investigated blockchain's application in the public sector, specifically focusing on document and license management, offering insights relevant to the

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Nigerian Communications Commission (NCC). Their research posited that blockchain technology holds the potential to significantly reduce bureaucratic inefficiencies and enhance the efficacy of licensing processes through decentralization. In the realm of licensing services, blockchain has emerged as a promising tool for process optimization and fraud prevention. Similarly, Wu et al. [21] and Zhang et al. [22] delved into blockchain's application in copyright management and digital rights protection, underscoring its capacity to safeguard intellectual property and streamline licensing procedures. Collectively, these studies underscore the multifaceted benefits of blockchain technology in enhancing licensing processes across various sectors, including telecommunications regulation.

D. Case Studies and Implementation Challenges

Hughes et al. [23] provide practical insights through case studies on blockchain implementation in government services, encompassing licensing. Their analysis highlights challenges like system integration and stakeholder buy-in. Despite blockchain's evident benefits, concerns persist regarding scalability, interoperability, and regulatory frameworks, prompting further investigation. This study aims to build upon existing research, leveraging diverse disciplinary perspectives to enrich the literature on blockchain applications in regulatory contexts. The focus remains on developing a blockchain system for licensing services tailored to the Nigerian Communications Commission's needs.

E. Blockchain in the Nigerian Context

Adebayo et al. [24] delved into the challenges and opportunities of blockchain in Nigerian public services. They emphasize the importance of infrastructure and digital literacy for successful implementation despite the technology's promise. This review offers a concise summary of the main themes and contributions in the field, laying the groundwork for a comprehensive examination of how the NCC can integrate blockchain technology to improve its licensing services.

Computing introduced software licensing and digital copyright, shaping a business model for proprietary software publishers [25]. Various validation methods have since emerged, impacting the industry. Software licensing controls access to software and digital intellectual properties, ensuring fair compensation for owners. Blockchain is depicted in Figure 1 as a means to validate software licenses.

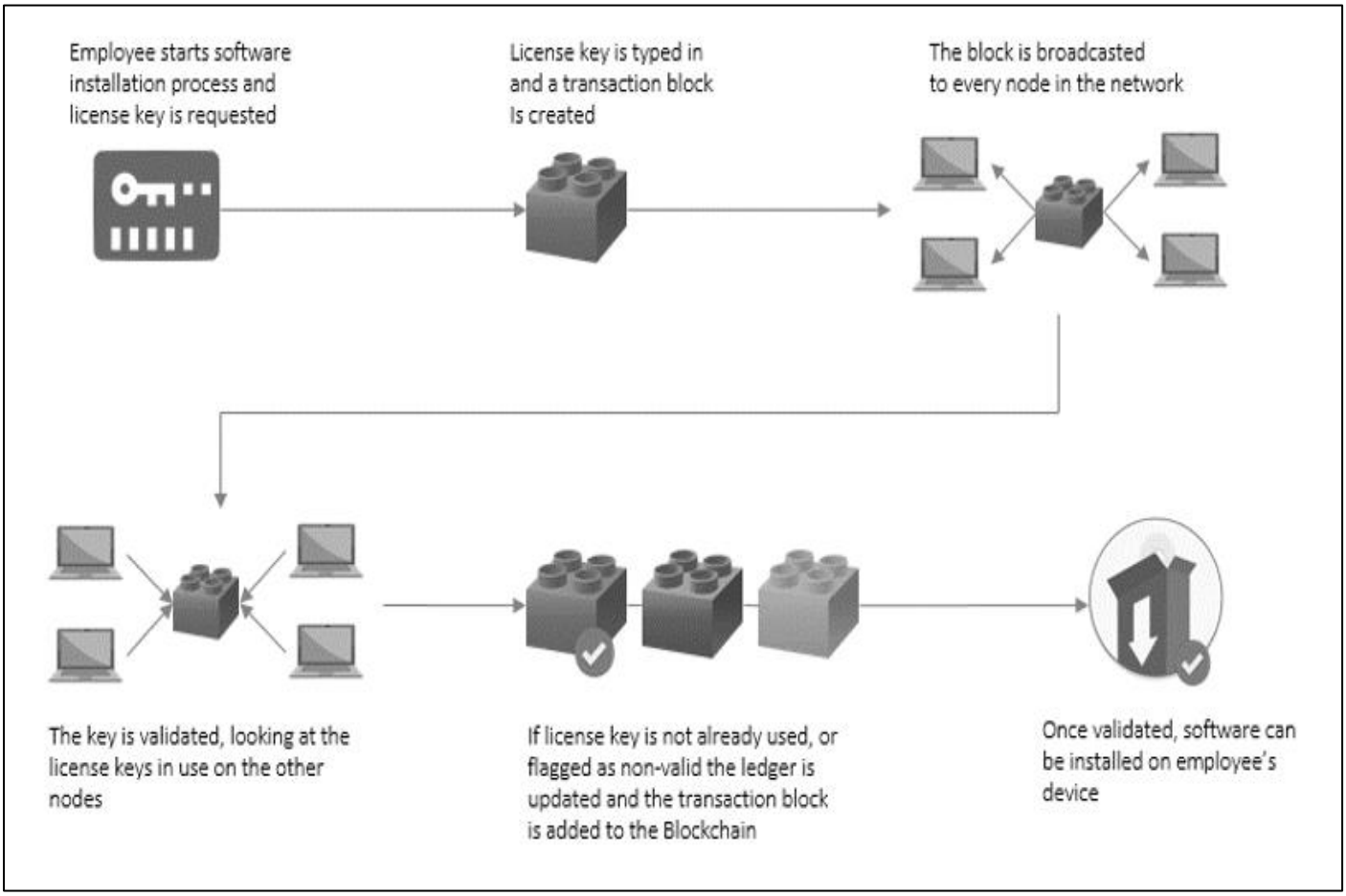

Fig 1: Concept of Blockchain Licensing

Smart contracts are like machines handling complex transactions, requiring no intermediaries, as described by [26]. In traditional transactions, lawyers or notaries manage complex transactions, delaying delivery until terms are met, but with smart contracts, transactions are instant once conditions are verified, as depicted in Figure 2.

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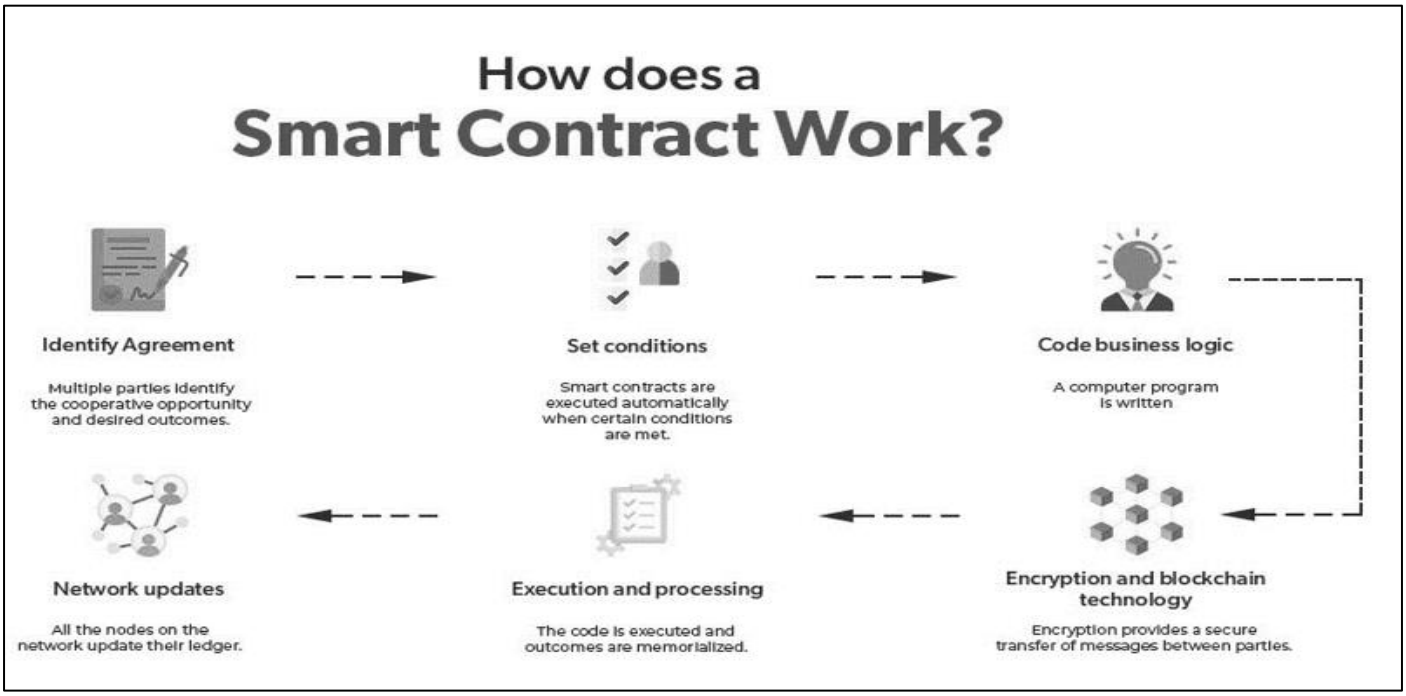

Fig 2: Concept of Smart

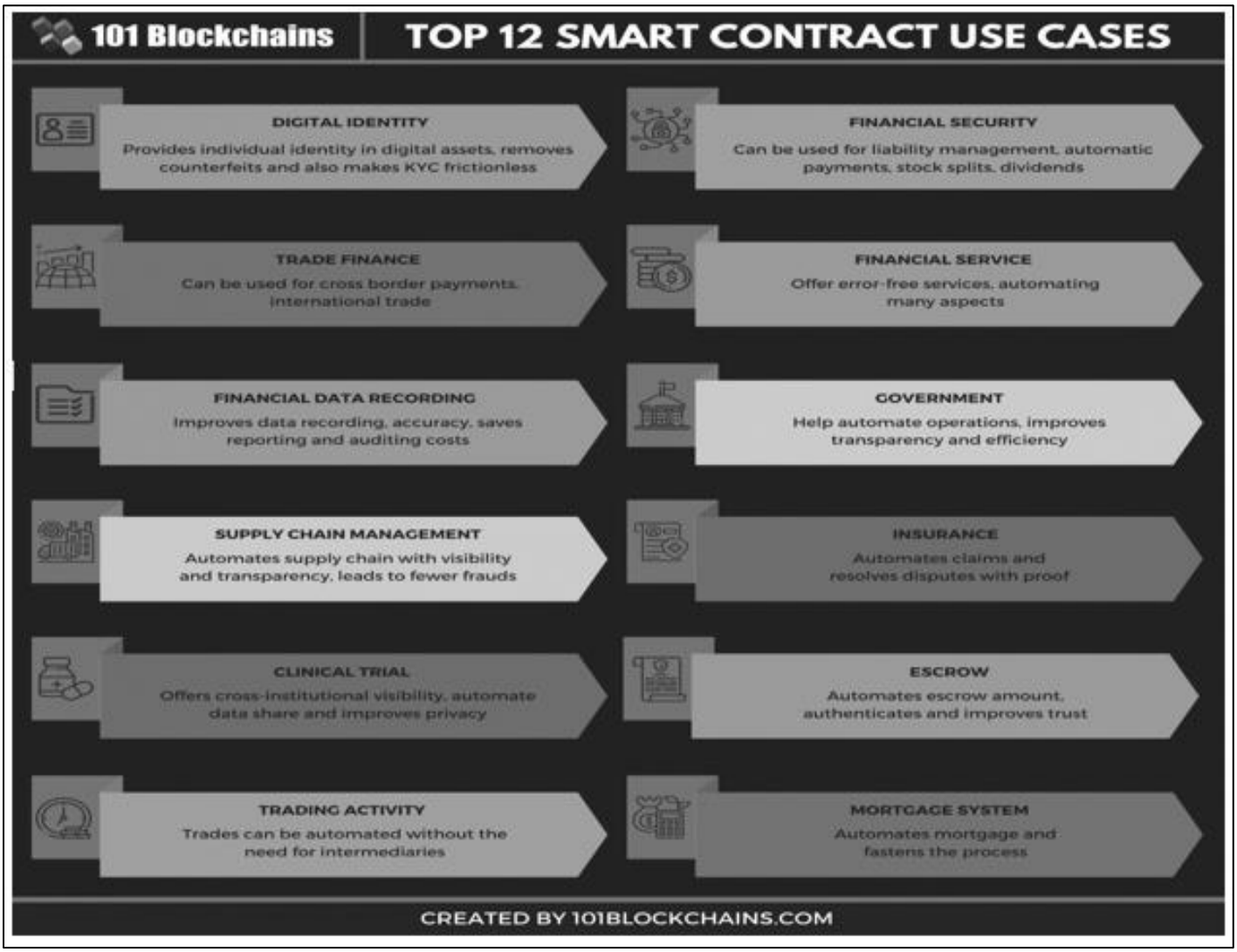

Fig 3: Uses of Smart Contract by 101Blockchains

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➢ *Blockchain License*

Software license validation methods deter piracy and safeguard authors' rights, while license audits rectify non-compliance [27]. This research explores NCC license validation methods and explores the benefits of Blockchain-based validation and management.

Blockchain integrates existing technologies uniquely, with applications spanning supply chain, insurance, finance, and certification digitization. Integrity and traceability are crucial for software protection and license management [28].

Figure 4 illustrates additional industrial blockchain applications. Cryptographic hardware and software ensure product monitoring, limiting licensed product production [28]. Blockchain's immutability and decentralization enhance security and trust, safeguarding personal data and facilitating transactions with approved entities in Nigeria. A blockchain-based certificate system improves license tracking, from issuance to expiration, reuse, reassignment, or archiving.

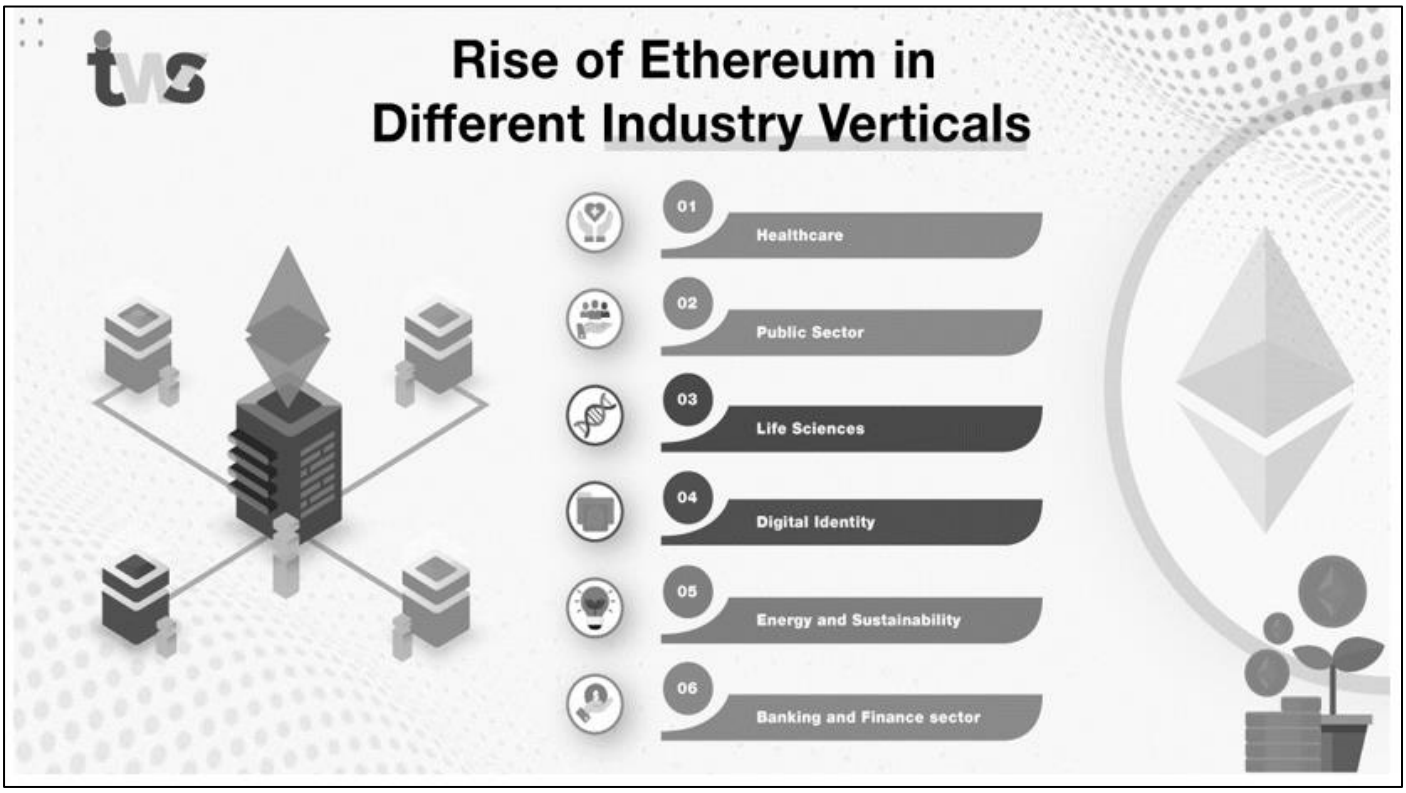

Fig 4: Ethereum Concept

To establish unique digital licenses on blockchain, non-fungible tokens representing various licenses are generated, with each token assigned a numerical format. Companies register for a userID, enabling access to their blockchain-stored license number. A theoretical framework outlines how blockchain manages, validates, and verifies software licenses, aiding understanding of design, features, value, and challenges. A truly decentralized blockchain may lack a single authority [29]. In the United States, the absence of a federal data privacy law results in varied sector-specific regulations, with ongoing efforts to enact comprehensive federal privacy legislation [30]. States like California implement additional data protection measures, while debates continue regarding federal privacy laws, potentially impacting blockchain deployment [31].

Software licenses grant users permission to utilize software products, services, or features under specified terms [32]. Blockchain technology ensures secure, transparent transaction and data management [33].

III. SOFTWARE MODEL

The author developed a blockchain-based licensing software, detailing its methodology covering requirement analysis, design, development, testing, implementation, and review [34]. Agile methodology was chosen for its iterative development approach, fostering collaboration and flexibility [35]. Unlike Waterfall, Agile allows simultaneous development and testing, emphasizing adaptability and continuous communication. It suits dynamic environments like software development, enabling adjustments in uncertain circumstances.

Here's a software model for the development of a blockchain system for licensing services for the Nigerian Communications Commission (NCC):

➢ *User Registration and Authentication: Applicants register on the blockchain platform and undergo authentication to ensure the security and validity of their applications.*

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➢ *Payment Processing Module:*

- Calculate Administrative Fees: The system calculates the administrative fee, which is 5% of the total cost of the license.
- Payment Verification: Once the applicant pays the administrative fee, the system verifies the payment to initiate the license processing.

➢ *Document Submission and Verification:*

- Document Upload: Applicants submit required documents such as CAC company registration form, CAC certificate, FIRS Tax Clearance Certificate, and NIN or other valid government-issued ID cards.
- Document Verification: The NCC verifies the authenticity of the submitted documents to ensure compliance with licensing requirements.

➢ *Technical Review Module:*

- Company Profile Review: NCC experts review the applicant's company profile to assess its technical capabilities and specialization.
- Technical Staff Assessment: The system schedules interviews with the applicant's technical staff to evaluate their expertise and experience in the relevant field.

➢ *Decision Making Module:*

- Analysis of Reports: NCC management analyzes all submitted reports to make informed decisions regarding license issuance.
- Transparency and Bias Reduction: The system ensures transparency and reduces bias in the decision-making process to provide equal opportunities for all applicants.

➢ *Fees and Pricing Module:*

- License Payment: Applicants make payments for the license once their application is approved.
- Issuance of License: Upon payment confirmation, the system initiates the license processing, documentation, and issuance process.

➢ *Notification and Communication Module:*

- Email/Phone Engagement: The system sends notifications to applicants via email or phone to keep them informed about the status of their application and payment.

➢ *Dashboard and Reporting:*

- Applicant Dashboard: Applicants have access to a dashboard to track the progress of their application and view any pending actions.
- Reporting: The system generates reports for NCC management to monitor the licensing process and make data-driven decisions.

This software model streamlines the licensing process, enhances transparency, and ensures fairness in license issuance for the Nigerian Communications Commission. Additionally, the integration of blockchain technology provides security, immutability, and transparency to the entire process. Figure 5 depicts the system architecture, illustrating component functions and connections.

Figure 5 portrays the system architecture, delineating the interaction among system components. Users initiate license applications, which undergo review and approval by NCC Staff according to predefined criteria. Upon approval, payment verification is conducted by NCC Staff. User data is securely stored in both NCC and Cloud databases. Subsequently, smart contracts validate adherence to NCC policies, applicant qualifications, and generate tokens linked to User IDs. These transactions undergo validation across network nodes, contributing to the creation of new blocks within the blockchain. Once validated, license tokens are activated and stored in cloud databases, thereby finalizing the issuance process.

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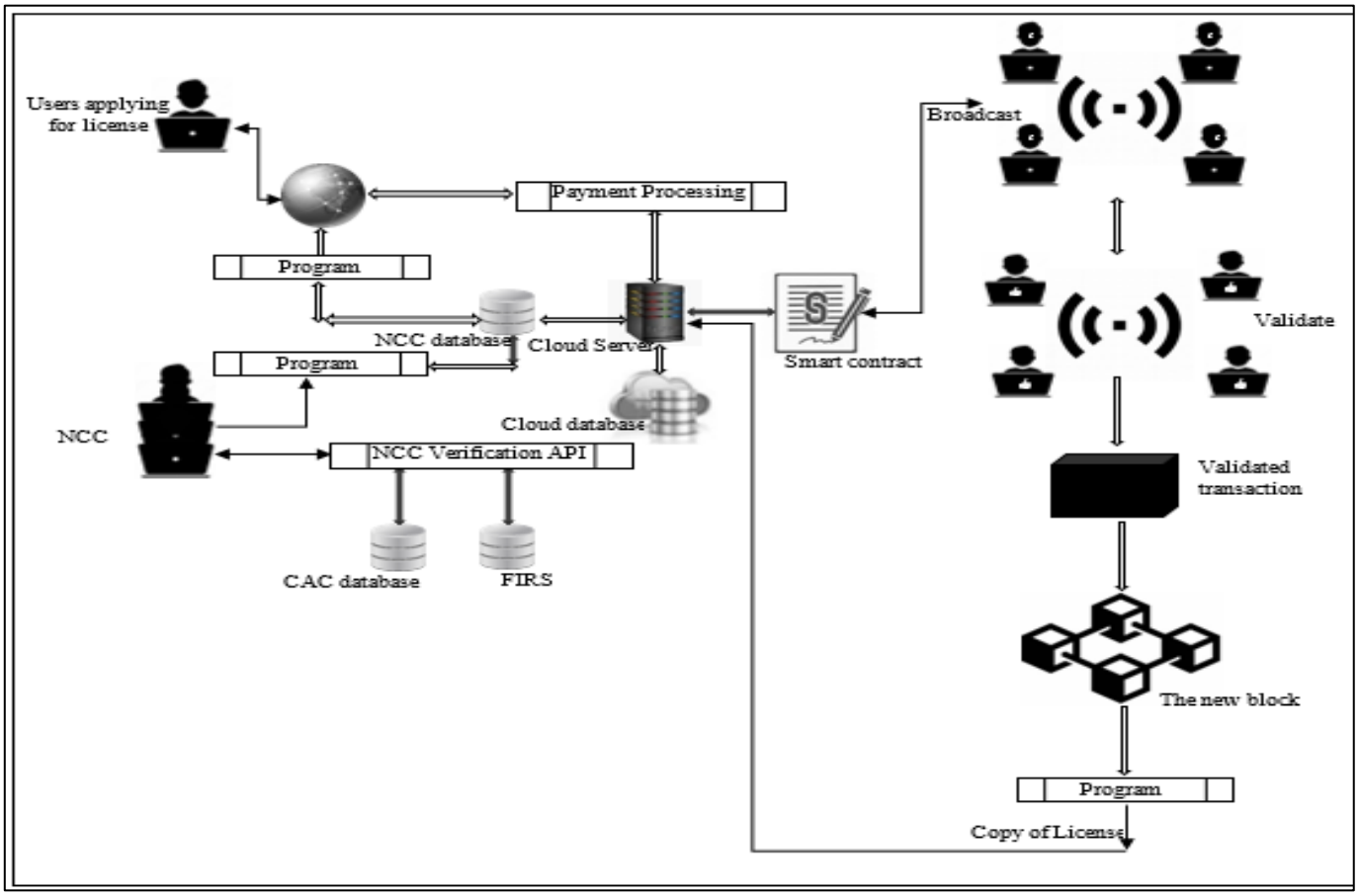

Fig 5: System Architecture Diagram

IV. METHODOLOGY

Methodology for the Development of a Blockchain System for Licensing Services for Nigerian Communications Commission using Agile:

Table 1: Methodology

Step	Phase	Description
Step 1	Define	Determine what work is required to be done, what is required to do it and how it will be done in the current iteration
Step 2	Design	Plan how to build the requirements into a product
Step 3	Build	Transform the design into a tangible product.
Step 4	Test	Validate that the system operates as intended.
Step 5	Release	Provide the system to NCC for trial operation.
Step 6	Review	This will be an upgrade or maintenance of the system

By following an Agile approach, the development team can deliver a blockchain system for licensing services that meets the needs of the Nigerian Communications Commission in a flexible, iterative, and collaborative manner.

V. RESULT

Test data plays a crucial role in validating system functionality, encompassing both inputs and outputs necessary for software testing. This data can be generated manually or automatically, depending on the specific requirements of the testing process. In the context of blockchain licensing, test data covers various aspects, including user and company information stored on both the web application and the blockchain. This information includes essential details such as wallet IDs and user IDs. Additionally, telecom certificates contain vital license token data, including the type of license, category, expiration date, and status. The wallet ID generated from MetaMask serves as the administrative account within the blockchain system. Transaction details, including user IDs, license tokens, dates, timestamp, admin wallet IDs, and transaction IDs, are also part of the test dataset. Moreover, license status and history, such as validity and expiration dates, are accessible and verifiable on the blockchain using license. To provide practical illustrations, examples of test data are presented in Table 2, while corresponding interfaces for system validation and result are depicted in Figures 6 to 10.

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Figure 6 depicts the comprehensive application process flow for the blockchain-based licensing services developed specifically for the Nigerian Communications Commission (NCC). This graphical representation offers a step-by-step overview of the entire licensing procedure, starting from the initial application phase through to the verification of license documents and eventual issuance of the license.

Table 2: Test Data

First Name	Last Name	Gender	Date of Birth	Email ID	Address	Phone	Password	Retype password
Alice	Smith	F	1990-01-01	alice.smith@example.com	123 Main Street New York NY 10001	(212) 555-1234	alicepassword123	alicepassword123
Bob	Jones	M	1985-02-02	bob.jones@example.com	456 Second Avenue Los Angeles CA 90001	(213) 555-2345	bobpassword456	bobpassword456
Charlie	Brown	M	1995-03-03	charlie.brown@example.com	789 Third Boulevard Chicago IL 60001	(312) 555-3456	charliepassword789	charliepassword789
Diana	Lee	F	2000-04-04	diana.lee@example.com	101 Fourth Circle Houston TX 70001	(713) 555-4567	dianapassword1010	dianapassword1010
Eric	Wang	M	1998-05-05	eric.wang@example.com	202 Fifth Square Phoenix AZ 80001	(602) 555-5678	ericpassword2020	ericpassword2020
Chinwedu	Okoafor	F	21/121985	chibest@iwuchi.com	45 Nzam Street, Aba	08025068986	Kls9de&7L	Kls9de&7L

- *Account Creation Page*

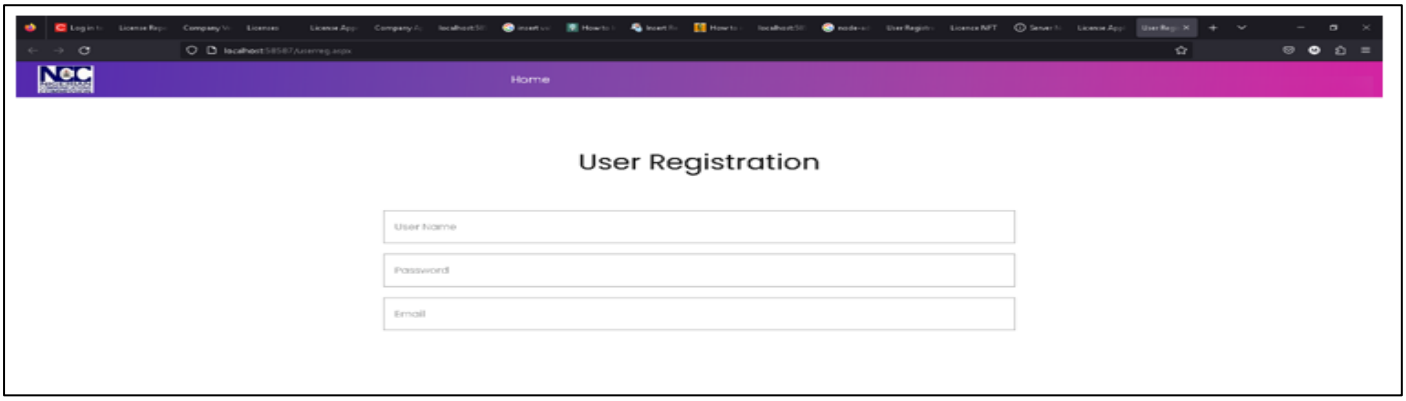

Fig 6: User Account Creation Page

- *Login Page*

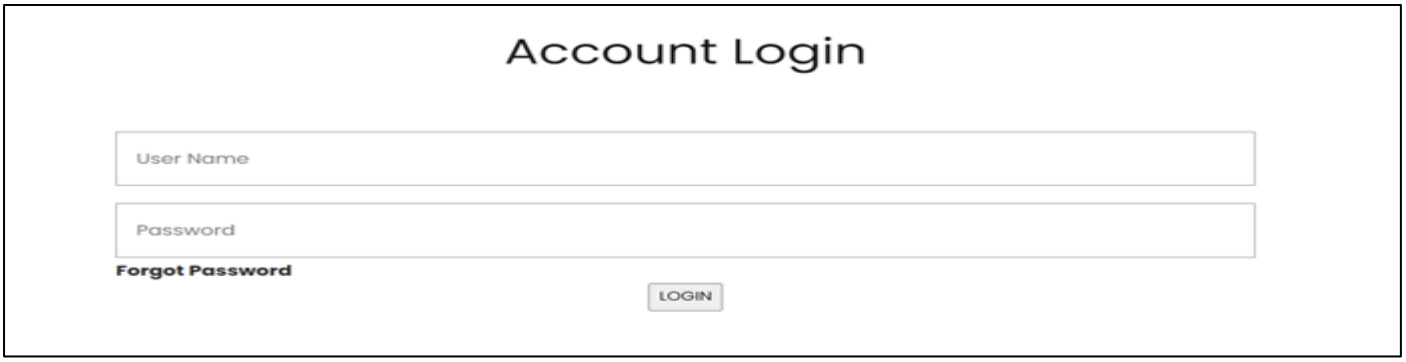

Fig 7: Admin/User Login Page

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➢ *Registration Page*

- *License Applicant Page*

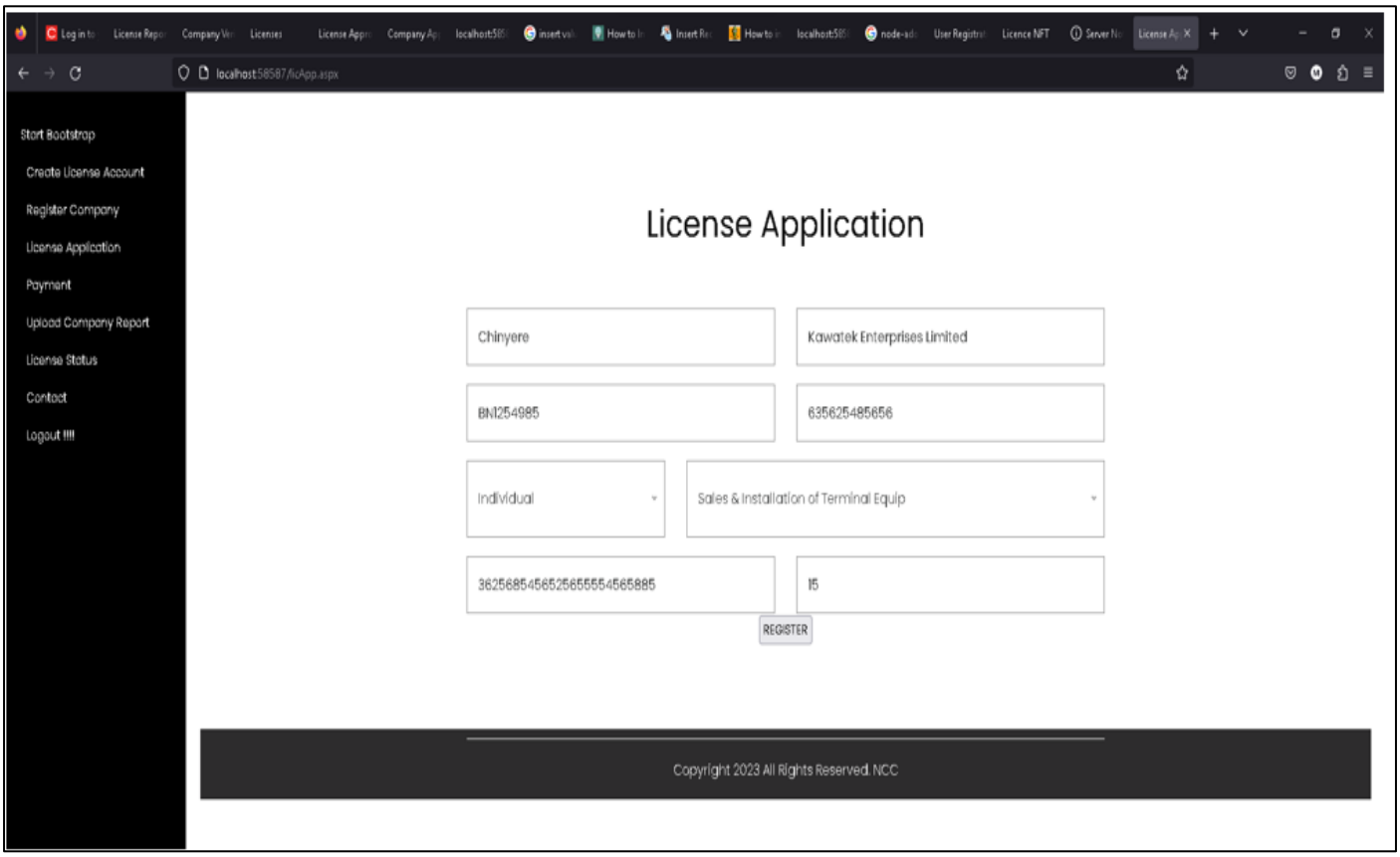

Fig 8: License Application Page

- *Blockchain License Management Page*

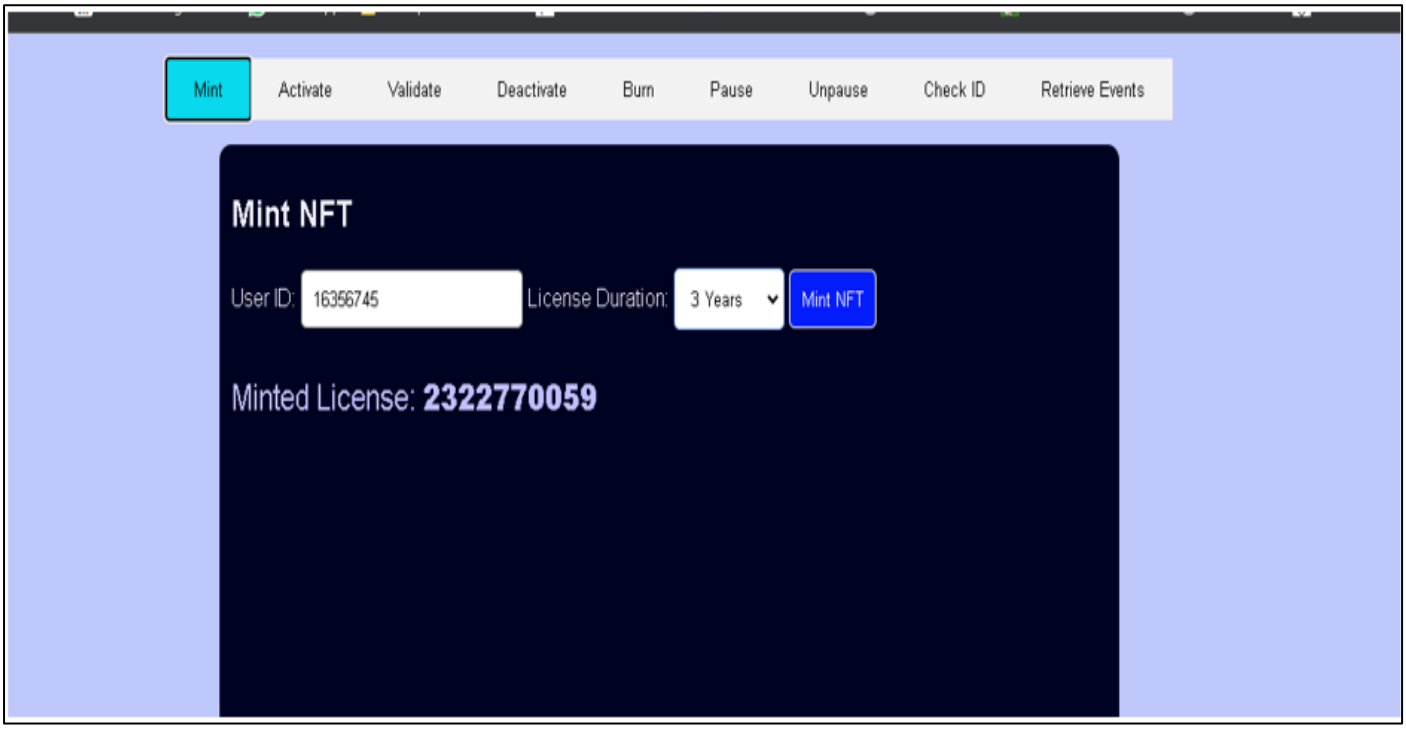

Fig 9: Blockchain Management Page

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- *License Event Page*

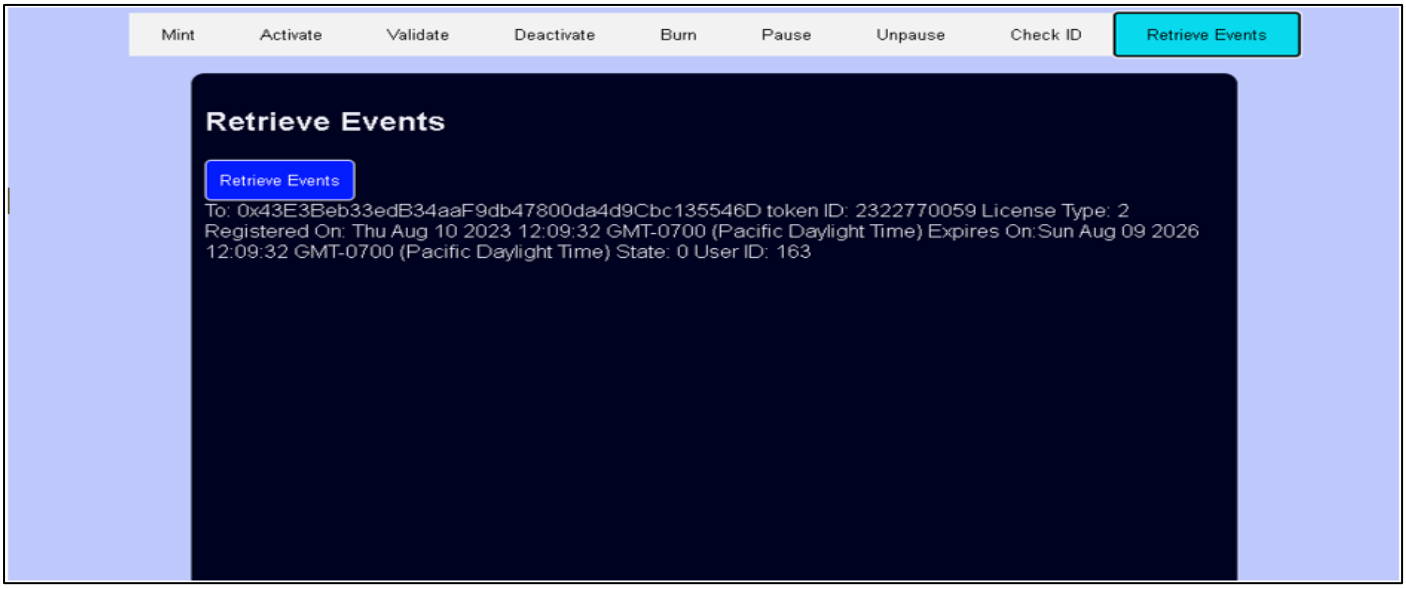

Fig 10: Blockchain License Report Page

To generate the required result and compare the speed at which a license is minted, the applicants follow this process: Figure 6 license applicant creates an account, an email for verification is sent to the applicant to the validate the account. In figure 7, the applicant's login to apply for license if the login is successful, then applicant uses the form in figure 8 to apply for license. After applying for license, Admins login using form 7 verify application documents, payments, and mint token ID which serves as the license. Admin uses applicants userID to generate license token which is shown in figure 9. Figure 10 is the blockchain report page showing the virtually all the information about the license. To facilitate the efficient generation of licenses and assess the processing speed, applicants undergo a structured process, as illustrated in the following figures:

- Figure 6 - Account Creation: The license applicant initiates the process by creating an account. Upon completion, an email containing a verification link is dispatched to the applicant to authenticate the account.
- Figure 7 - Applicant Login: Subsequently, the applicant logs in using the credentials established during the account creation phase. Successful login grants access to the license application interface.
- Figure 8 - License Application: Utilizing the provided form, the applicant proceeds to submit the necessary details and documents to apply for the license.
- Figure 9 - Admin Verification and Token Minting: Administrators, upon logging in using the designated form, undertake the verification of application documents and payment status. Upon successful verification, administrators proceed to mint the license token, which serves as the official license for the applicant.
- Figure 10 - Blockchain Report: The blockchain report page offers a comprehensive overview of the generated license, encompassing pertinent details and information.

The time required to mint a license involves writing transactions to the blockchain. While read calls do not incur significant time or resources, write calls necessitate mining and consume gas due to their impact on the blockchain's state and the consensus mechanism. To accurately measure the time spent on a write call, denoted as T1 - T0, T0 is recorded before sending the transaction, and T1 is captured upon receiving the confirmation message.

For instance, during the application test conducted on a Dell Precision Mobile Workstation 7760 equipped with a Xenon Processor, 8 cores, 64GB DDR4 RAM, and 2TB SSD running Windows 11, Ganache, SQL Server, Visual Studio, Node.js, and MetaMask, the following timing data was observed:

- T0 = 12:01:25
- T1 = 12:01:33

Therefore, the time taken to mint a license, calculated as 12:01:33 - 12:01:25, equals 8 seconds. This timeframe provides valuable insight into the efficiency of the license generation process.

VI. CONCLUSION

Blockchain licensing and smart contracts offer solutions to piracy and manual operations, ensuring trust and transparency. They streamline licensing, promote renewal, and enforce transparency. Challenges include decentralization, trust, and regulation. The system can provide real-time data to decision-makers. This innovation enhances software license management, offering flexibility and security.

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➢ *The Research Identifies Limitations and Suggests Future Directions:*

- Exploration of various blockchain licensing models like hashed-based or hybrid.
- Application of the proposed approach to diverse use cases like medical records or financial data.

➢ *Future Research Directions Include:*

- Empirical studies to assess user experience and satisfaction.
- Examination of legal and regulatory implications.
- Exploration of social and ethical impacts of blockchain licensing systems.

RECOMMENDATION

Further research on blockchain APIs for interdepartmental integration. Explore social, ethical impacts of blockchain licensing systems.

➢ *Recommended Researchers:*

- Eman-Yasser Daraghmi, et al., on blockchain-based academic records access [36].
- Weiru Chen, et al., on blockchain's impact on international student workflows [37].
- J. Kang and M. Liu, on blockchain-based software license management [38].
- Manuel Beltran, envisioning blockchain's role in scientific publishing [39].

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