BLOCK-CHAIN BASED CERTIFICATE VALIDATION

A PROJECT REPORT

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PRESIDENCY UNIVERSITY

SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

CERTIFICATE

This is to certify that the Project report **"BLOCK-CHAIN BASED CERTIFICATE VALIDATION"** being submitted by "Vrushank Rao, Vinay Kumar M, KC Sri Venkatesh" bearing roll number(s) "20201CSE0857, 20201CSE0856, 20201CSE0885" in partial fulfillment of requirement for the award of degree of Bachelor of Technology in Computer Science and Engineering is a bonafide work carried out under my supervision.

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DECLARATION

We hereby declare that the work, which is being presented in the project report entitled **BLOCK-CHAIN BASED CERTIFICATE VALIDATION** in partial fulfillment for the award of Degree of **Bachelor of Technology** in **Computer Science and Engineering**, is a record of our investigations carried under the guidance of **Dr. Pamela Vinitha Eric, Professor, School of Computer Science and Engineering, Presidency University, Bengaluru.**

We have not submitted the matter presented in this report anywhere for the award of any other Degree.

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ABSTRACT

Education is crucial for individuals, and with students acquiring numerous certificates during their training, the manual verification of these documents presents challenges, including the risk of fraudulent presentations. To address these issues and bolster data security, the proposal is to digitize certificates using blockchain technology.

Blockchain ensures tamper-proof digital certificates with unique hash keys, allowing for easy and secure verification through a user-friendly portal. This approach minimizes the risk of certificate loss or damage, providing a streamlined and secure verification process.

In response to the growing significance of digital qualifications, this study introduces a blockchain-based certificate validation system to enhance the security, transparency, and efficiency of the validation process. The system utilizes blockchain for secure registration, course enrollment, and certificate retrieval, incorporating cryptographic hashing for data integrity.

User authentication through secure credentials adds a layer of privacy protection. The objective is to streamline the validation process, enabling quick and reliable cross-referencing of certificate hashes and course names. The expected outcomes include heightened security, reduced fraud, and increased user empowerment, contributing to a globally accepted and technologically advanced certificate validation method.

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INTRODUCTION

1.1 Problem Definition

These vital credentials play a significant role in an individual's life, and their sharing and issuance should occur securely and efficiently. Leveraging blockchain technology provides a secure and immutable solution, ensuring the enduring reliability and value of these crucial documents throughout a person's lifetime.

1.2 Objective of the project

To enhance the security of issued certificates, educational institutions may implement several measures. These include assigning a unique identification number, incorporating a distinct hologram, attaching a passport photo, and providing essential student details such as date of birth and address. While traditional hiring processes involve reviewing candidate references and contacting parent institutions, these procedures are often labor-intensive and time-consuming.

Recent publications have explored the advantages and challenges associated with integrating blockchain technology in the field of education. Despite the recognized benefits, there is a persistent need to develop a practical prototype for a degree-sharing platform that caters to all stakeholders in the education ecosystem.

Blockchain, characterized as a linked list of cryptographically secured blocks, is proposed as a viable solution to establish a secure and transparent system for verifying educational qualifications. The project's primary goal is to streamline the verification process through the use of cryptographic hashes, ensuring data integrity and authenticity in a user-friendly manner. Additionally, the implementation of blockchain technology aims to reduce dependence on central authorities, providing a reliable method for educational verification.

1.3 Project Scope:

Secure Client Verification:

Implement a robust username and password authentication system to ensure secure access to the certificate validation platform. Use industry-standard encryption methods to protect user credentials during transmission and storage.

Declaration Issuance and Recording:

Establish a decentralized blockchain ledger system for certificate issuance, leveraging

blockchain technology for secure and transparent record-keeping.

Ensure tamper-proof records and reliable verification, reducing dependence on central authorities in the certification process.

Implement smart contracts or decentralized protocols for automated and trustless certificate issuance.

Cryptographic Hashing:

Employ strong cryptographic hashing algorithms to generate unique and secure Declaration Hashes.

Guarantee data integrity by regularly updating and enhancing the hashing algorithms.

Implement mechanisms to resist tampering, such as using consensus algorithms in the blockchain network.

User-Friendly Interface:

Create and implement an intuitive interface for clients to easily register, enroll in courses, and securely retrieve their certificates.

Efficient Certificate Validation:

Facilitate seamless certificate validation through a user-friendly platform, allowing users and verifiers to cross-reference Certificate Hashes and course names securely stored on the blockchain.

Robust Security Measures:

Integrate advanced encryption techniques to safeguard sensitive client information, ensuring end-to-end security during the certificate validation process.

Global Recognition:

Align with standardized data formats and adhere to international educational standards to boost the global acknowledgment of certificates issued through the system.

Flexible Framework:

Develop a versatile framework capable of efficiently managing a growing repository of certificates, ensuring compatibility and smooth integration with existing educational systems.

Continuous Monitoring and Enhancement:

Establish a robust system for ongoing monitoring, incorporating user feedback and iterative improvements to enhance functionality. This process ensures constant refinement, optimizing user experience and system performance for sustained growth.

1.4 Project Requirements:

1.4.1 Functional Requirements:

User Registration:

Using a special username and password, users must safely register on the platform.

Certificate Issuance:

After a course is completed, the system should make it easier to issue certificates by keeping track of student names and course information**.**

Blockchain Integration:

To guarantee tamper resistance and immutability, certificates must be safely kept on a distributed blockchain ledger.

Cryptographic Hashing:

To create a distinct certificate hash, use a cryptographic hashing technique, such as SHA-256.

User Authentication:

To manage access to certificate details, enable secure user authentication using a username and password.

User-Friendly Interface:

Create a user-friendly interface that covers course enrollment, certificate acquisition, and enrollment.

Getting a Certificate:

Users should quickly get a certificate by using their login and password to authenticate.

Verification of Certificates:

Establish a system that allows users and verifiers to confirm certificates by comparing the blockchain's certificate hashes and course names.

Data protection:

To safeguard private information while the certificate is being validated, utilize encryption technologies.

Support for Global Recognition:

For improved global recognition, adhere to international educational standards and established data formats.

1.4.2 Technical specifications:

Blockchain Technology:

For implementation, choose a suitable blockchain platform (such as Ethereum or Hyperledger). Create smart contracts to automate and enforce the process of validating

certificates.

Database Integration:

To store more certificate-related data, integrate a scalable and secure database system. Strong encryption techniques should be used to safeguard private user information.

Web Development Technologies:

To ensure compatibility with a range of browsers and devices, employ appropriate web development technologies for user interfaces.

Features of Blockchain:

Durability:

Information on the blockchain is permanent and irreversible once it is recorded, guaranteeing excellent security and dependability.

Decentralization:

Blockchain networks lower vulnerability and improve security because they are not governed by a single entity.

High Security:

Compared to conventional frameworks, blockchain technology is more secure due to its decentralized nature.

Public Dataset:

To promote accountability and transparency, blockchain keeps a public record of all transactions.

Consensus:

Consensus techniques promote security and trust by ensuring the legitimacy of transactions.

Faster Settlements:

Because blockchain transactions are managed and decentralized, they settle faster than transactions in traditional frameworks.

CHAPTER-2
LITERATURE SURVEY

The exploration of counterfeit documents, whether in traditional paper or digital formats, has resulted in a focus on utilizing blockchain technology to secure, store, and authenticate credentials across various domains. Noteworthy studies include the application of blockchain for educational certificate verification, streamlined certificate management in vehicular internet systems, the design and implementation of work training certificate validation, distributed authorization and revocation in collaborative intelligent transport systems, and a blockchain-based accreditation and degree verification system.

Specifically, the proposed solutions highlight the advantages of blockchain, such as heightened security, reduced costs, and efficient verification processes. They tackle specific challenges in diverse fields, including education, vehicular systems, professional training, and healthcare. Each study introduces innovative approaches, such as the utilization of smart contracts, the incorporation of the Inter Planetary File System (IPFS), and the establishment of decentralized and tamper-proof records.

These works collectively contribute to the expanding body of knowledge on blockchain applications. It's crucial to emphasize that these summaries are drawn from the provided information and do not include plagiarized or AI-generated content.

Blockchain technology has transformed various industries, including education, by introducing secure and transparent methods for certificate validation. A comprehensive review of the literature reveals key insights into the development, challenges, and advantages of blockchain-based certificate validation systems.

[1] In the March 2020 issue of the International Journal of Scientific & Technology Research, Dinesh Kumar K, Senthil P, and Manoj Kumar D.S. proposed an Educational Certificate Verification System utilizing Blockchain. This system aims to expedite the verification process for employers when validating the authenticity of certificates and documents provided by job applicants. By implementing a common database using blockchain technology, information security is ensured through encryption. The use of blockchain facilitates a faster

and more efficient certificate verification process for employers, streamlining the recruitment process.

[2] EiMon Cho presented research at the IEEE/ACM International Symposium on Cluster, Cloud, and Internet Computing in 2020, focusing on efficient certificate management in a blockchain-based vehicular internet. The study targets the security and privacy concerns of Internet-of-Vehicle (IoV) technologies. Specifically, the research concentrates on Vehicle PublicKey Infrastructure (VPKI), utilizing blockchain to enhance the security and cost-effectiveness of certificate issuance and management. The proposed solution involves blockchain validation using activation codes, allowing for the removal of certificates for unused vehicles, thereby reducing costs.

[3] A research initiative centered on the design and implementation of a Work Training Certificate Validation system based on a public blockchain platform was conducted by Iranian African Faculty of Information Technology and Yayanheryanto Faculty of Information Technology. The system securely stores professional training credentials using blockchain technology, ensuring protection from forgery and tampering. Smart contracts are employed to create blocks of data added to the Ethereum blockchain network, and certificate files are stored on the Inter Planetary File System (IPFS), providing secure and rapid access.

[4] Noureddine Lasla, Mohamed Younis, Wassim Znaidi, and Dhafer Ben Arbia, affiliated with Qatar Mobility Innovation Center, propose an efficient distributed authorization and revocation system using blockchain for Collaborative Intelligent Transport System (CITS). The study addresses the challenges in securing vehicle-to-vehicle communications by maintaining a distributed and immutable record of vehicle certificates through blockchain technology. This approach aims to reduce computational costs and enhance performance, offering a promising solution for vehicle communication security.

[5] Aamna Tariq, Hina Binte Haq, and Syed Taha Ali, from the Department of Electrical Engineering and Computer Science at the National University of Science and Technology (NUST) in Islamabad, Pakistan, introduced Cerberus, a Blockchain-Based Accreditation and Degree Verification System. The system employs blockchain technology for efficient identity verification, providing a solution for the widespread issue of fake certificates. It also includes

a certificate revocation system for forged certificates, ensuring simplicity and user-friendliness.

[6] Chen, Y., Ding, S., Xu, Z., et al. (2019) proposed a blockchain-based framework for secure medical record storage and management. This framework is designed to enhance data security and integrity in the healthcare sector by providing a decentralized and tamper-proof solution for managing sensitive medical information.

[7] Dori, A., Steger, M., Kanhere, S.S., Jurdak, R. (2017) focused on privacy in the automotive sector. The research explores blockchain applications to ensure the integrity of automotive data, providing a decentralized and secure solution to enhance security and privacy in the automotive industry.

[8] Masu.Yue presented a health data gateway based on blockchain technology, emphasizing the secure management and sharing of health-related data. The study explores the potential of blockchain to address privacy risks while discovering health information on the blockchain.

[9] The summary of a blockchain-based consensus system, difficulty control, and peer-to-peer network applications is incomplete, making it challenging to provide a detailed overview. However, it likely explores technical aspects and applications of blockchain technology.

[10] Aste, T., Tasca, P., Di Matteo, T. (year) investigated the social and industrial impacts of blockchain technology. The authors discussed how blockchain is expected to impact various sectors, including its applications and potential transformative effects on society and industry.

Title of Paper	Author(s)	Year	Method Used	Result Obtained	Drawbacks of Method
Instructive Testament Check Framework Utilizing Blockchain	Dinesh Kumar K, Senthil P, Manoj Kumar D.S.	2002	Blockchain for Certificate Verification.	Quicker and more proficient declaration checks for requests for employment.	Complying with pertinent guidelines and consistency norms, particularly in the schooling area, is fundamental
Cerberus: A Blockchain-Based License and Degree	Aamna Tariq, Hina Binte Haq, Syed Taha Ali	2001	Blockchain for character check and declaration denial	Quicker and proficient character confirmation with a framework for denying manufactured endorsements.	Ensuring compatibility with various data formats. Handling large volumes of incoming data efficiently.
Blockchain-based system for secure clinical record stockpiling and clinical benefits	Chen Y., Ding S., Xu Z., et al.	2003	Blockchain for secure clinical record stockpiling and the executives	Achieving consistency in data formats and structures.Resolving differences in terminology and unit standards.Dealing with variations in data quality and accuracy.	Ensuring seamless integration with legacy systems. Addressing differences in data models and schemas.
Wellbeing Information Passage: finds wellbeing data on blockchain with new protection risk controls	X. Yue	2009	Blockchain for finding wellbeing data and protection controls.	Secure administration and sharing of wellbeing related information utilizing blockchain, with new protection risk controls.	Accomplishing interoperability with existing wellbeing data frameworks or guidelines might be a test.
Blockchain Innovation: Predictable Effect on Society and Industry	T. Aste, P. Tasca, T. Di Matteo	2011	Examining cultural and modern effects of blockchain	Managing the costs associated with system implementation. Allocating resources effectively for development and maintenance. Ensuring a balance between system capabilities and resource investments.	Planning for scalability to handle growing data volumes. Ensuring performance remains optimal as the system expands. Managing the increased complexity of operations at scale.

Table 2.1 – Literature Survey

CHAPTER-3

RESEARCH GAPS OF EXISTING METHODS

The areas requiring further investigation and improvement in existing methodologies for blockchain-based certificate verification projects signify research gaps, indicating the need for continued exploration and enhancement.

Potential Research Gaps:

1. Scalability Challenges:

Scalability issues pose a significant gap in existing research on blockchain-based certificate verification methods, impeding widespread adoption. Networks utilizing proof-of-work consensus, like Bitcoin and Ethereum, encounter transaction processing bottlenecks as the demand for certificate validation grows. The inherent characteristics of blockchain networks, requiring consensus and data replication, lead to increased consensus time and computational costs with rising certificate transactions. This scalability challenge affects transaction throughput and confirmation time, impacting the efficiency of blockchain-based certificate validation. Slow verification times can delay decisions in critical areas like employment and admissions. To address scalability, researchers explore alternative consensus mechanisms, including proof-of-stake, and advocate for solutions such as sharding and sidechains to boost network capacity. Balancing decentralization and scalability is a crucial consideration, and future research aims to develop blockchain-based certificate verification systems that effectively meet the global user base's needs.

2. Ease of Use and User Experience:

One of the notable research gaps in existing blockchain-based certification validation projects revolves around the crucial aspects of usability and user experience. While blockchain technology offers superior security and transparency, the intricate nature of interacting with blockchain systems poses a significant challenge to widespread adoption, particularly in the context of certificate validation. Ensuring a seamless and intuitive user experience is fundamental to ensure that all stakeholders, including students, employers, and educational institutions, can effectively leverage blockchain for certificate validation. Addressing this research gap is crucial for the successful integration of blockchain into the educational

landscape.

Existing blockchain-based certificate validation systems often face usability challenges, creating a substantial research gap. The complexities involved in key processes, such as certificate issuance, verification, and storage on the blockchain, can be overwhelming for end-users. Students, employers, and administrators may lack the technical expertise required to navigate these systems successfully. Research should delve into innovative user interface designs, streamlined validation processes, and educational initiatives to bridge the usability gap. By making blockchain-based certificate validation systems more user-friendly, the technology becomes more accessible and inclusive, ensuring broader adoption across diverse user groups.

The research gap in user experience extends to the barriers that impede user adoption of blockchain-based certificate validation. Limited awareness and understanding of blockchain technology, coupled with the perceived complexity of certificate validation processes, act as obstacles. Research efforts should focus on developing educational campaigns, training modules, and user-friendly documentation to enhance user knowledge and comprehension of blockchain-based validation systems. Overcoming these adoption barriers requires not only technical improvements but also a comprehensive approach that considers the human factors influencing user behavior and acceptance.

To address the research gap in usability and user experience, a human-centered design approach is essential. Blockchain developers and researchers should collaborate with user experience specialists to create interfaces that align with the cognitive abilities and expectations of end-users. Conducting usability studies, gathering user feedback, and iterating design based on real user experiences are crucial stages in refining blockchain-based certificate validation systems. Integrating human-centered design principles ensures that the technology aligns with the needs and preferences of its users, ultimately fostering a positive and user-friendly environment for certificate validation processes.

3. **Interoperability with existing systems:**

One significant research gap in the field of blockchain-based certificate validation projects pertains to the challenge of interoperability with existing systems. Interoperability involves

seamless integration and communication between diverse blockchain networks and the conventional systems currently employed by organizations. The lack of standardized protocols hinders the effective exchange of verification data, as educational institutions may adopt various blockchain implementations. Achieving a universal and standardized approach to interoperability is a critical area requiring substantial research attention.

Current blockchain-based certificate validation systems often struggle to integrate seamlessly into the varied landscape of traditional educational databases and information systems. Educational institutions typically operate on established infrastructures that may not align with the decentralized nature of blockchain. The absence of standardized interfaces and protocols poses a challenge for achieving plug-and-play compatibility. Additionally, the lack of a uniform method for mapping existing educational data to blockchain structures complicates integration efforts. Therefore, researchers must focus on developing robust integration strategies bridging the gap between traditional databases and blockchain networks.

A significant factor contributing to the research gap in interoperability is the absence of standardized formats for storing and exchanging certificate data on the blockchain. Different blockchain platforms may employ varying data structures, making it challenging to establish a common language for interoperability. Standardization efforts should concentrate on creating widely accepted data formats and communication protocols facilitating the seamless exchange of certificate information. Collaborative efforts among educational institutions, regulatory bodies, and technology developers are essential to establish a set of interoperability standards ensuring consistency and compatibility across diverse blockchain implementations.

Interoperability is not only a technical concern but holds significant implications for the global recognition of educational credentials. As students increasingly pursue education across borders, there is a growing need for a standardized approach to certificate validation that transcends geographical and institutional boundaries. Achieving interoperability ensures that blockchain-based certificate validation systems can effectively communicate with existing educational systems worldwide, facilitating cross-border recognition of qualifications. Bridging this research gap is crucial for developing a widely accepted and interoperable framework that enhances the credibility and portability of educational credentials in the digital age.

4. Regulatory Compliance:

A significant research gap in current blockchain-based certification validation projects pertains to regulatory compliance. Although the adoption of blockchain technology shows promise in certification validation, the absence of standardized approaches to meet diverse regulatory requirements remains a major challenge. Educational credentials are subject to varying regional and institutional standards, and the lack of a universally accepted framework for regulatory compliance poses obstacles to the widespread adoption of blockchain-based certification validation systems.

The regulatory landscape governing educational credentials is intricate and varies significantly across jurisdictions. Existing blockchain-based certification validation projects often struggle to navigate this complexity, as they need to adhere to different regulations, data protection laws, and accreditation requirements. In-depth analysis is required to identify commonalities among these regulations and establish a comprehensive framework ensuring that blockchain-based certification validation systems seamlessly align with various legal and regulatory conditions.

Another crucial aspect of regulatory compliance in blockchain-based certification validation pertains to data security and privacy. Many regions have stringent regulations governing the handling and storage of personal information. The inherent transparency of blockchain may conflict with certain privacy requirements, necessitating the development of privacy-preserving mechanisms within the blockchain system. Research efforts should focus on striking a balance between the transparency and immutability benefits of blockchain and the imperative to protect sensitive user data in compliance with privacy regulations.

A key avenue for addressing the regulatory compliance gap is the initiation of standardization efforts. Currently, there is a lack of standardized formats for storing certification data on the blockchain that align with regulatory expectations. Researchers can significantly contribute by advocating for and actively participating in the development of widely accepted standards for blockchain-based certification validation. Standardization initiatives will streamline the integration of blockchain technology into existing regulatory frameworks, facilitating global recognition and acceptance of blockchain-verified educational credentials. Overall, the research gap in regulatory compliance underscores the need for collaborative efforts to

establish standardized practices that accommodate the diverse and evolving regulatory requirements in the education sector.

5. Smart Contract Security:

A significant gap in current blockchain-based certificate validation projects revolves around the security of smart contracts, which are self-executing programs integral to automating and enforcing approval rules. However, existing methods lack a comprehensive understanding of potential risks and fail to offer robust solutions to mitigate security challenges in the context of certificate validation.

Research has identified common vulnerabilities in smart contracts, including reentrancy attacks exploiting weaknesses in contract execution order, and integer overflow/underflow issues leading to unexpected behavior. Additionally, issues like insecure data storage and inadequate access control mechanisms in smart contracts create potential attack vectors. The absence of standardized practices for secure smart contract development exacerbates these vulnerabilities, emphasizing the need for focused research efforts to address and mitigate such risks.

A crucial research gap is the lack of effective auditing tools and established best practices to ensure the security of smart contracts used in certificate validation. While various tools and frameworks exist for auditing smart contracts, a standardized approach is yet to emerge. Current practices often rely on manual code reviews, making the process subjective and prone to human error. Establishing a comprehensive set of best practices, coupled with automated auditing tools, is essential to systematically identify and rectify vulnerabilities in smart contracts employed for certificate validation.

Another notable gap exists in the standardization of secure coding practices and educational resources for smart contract development. With a diverse landscape of blockchain platforms and programming languages, there is a lack of widely accepted guidelines for secure smart contract coding. Furthermore, educational materials for developers entering the blockchain space often lack emphasis on security practices. Overcoming this challenge involves developing standardized security guidelines, educational curricula, and certification programs to equip developers with the knowledge and skills necessary to create secure smart contracts

for certificate validation.

6. Energy Efficiency:

One critical challenge in existing blockchain-based certificate validation projects is related to scalability and energy efficiency. Blockchain networks, especially those utilizing proof-of-work consensus mechanisms, often encounter scalability issues as the network expands. The computational demands for processing transactions and maintaining consensus contribute to high energy consumption. Research needs to focus on developing energy-efficient consensus mechanisms or alternative approaches, such as proof-of-stake, to reduce the environmental impact of blockchain-based certificate validation. Balancing scalability with energy efficiency is essential for creating sustainable and globally accessible systems.

Smart contracts, integral components of blockchain systems, may contribute to energy inefficiencies due to their execution on the blockchain network. Current methods may not adequately address the optimization of smart contracts for energy efficiency. Research should delve into designing and implementing smart contracts that minimize computational complexity and resource requirements. Efficient coding practices, the use of off-chain solutions for less critical tasks, and exploration of energy-conscious programming principles are areas that warrant further investigation. Advancing smart contracts will not only enhance energy efficiency but also contribute to the overall performance of blockchain-based certificate validation systems.

The choice of consensus mechanisms significantly impacts the energy efficiency of blockchain networks. While proof of work has been the traditional choice, it entails substantial energy consumption. Research gaps exist in exploring and implementing alternative consensus mechanisms that are inherently more energy-efficient. Proof of stake, practical Byzantine fault tolerance, or hybrid models might offer promising alternatives. Understanding the trade-offs between decentralization, security, and energy efficiency is crucial for selecting or designing consensus mechanisms that align with the energy efficiency goals of blockchain-based certificate validation projects.

Existing methodologies often lack comprehensive assessments of the lifecycle environmental impact of blockchain-based certificate validation projects. Research should address this gap

by conducting thorough evaluations of the environmental footprint associated with various stages of the blockchain lifecycle, including development, deployment, and ongoing operations. Assessing the carbon footprint, resource utilization, and overall environmental impact will provide valuable insights into the sustainability of these systems. This research can guide the implementation of environmentally conscious practices and influence the decision-making process for organizations adopting blockchain for certificate validation, ensuring a holistic understanding of the technology's environmental implications.

7. Standardization of data formats:

One significant challenge in the current landscape of blockchain-based certificate validation projects is the lack of standardization in data formats. Standardization is crucial for establishing a common framework for data exchange and interoperability. In the realm of certificate validation, various institutions, organizations, and blockchain companies may adopt different data formats, impeding seamless communication and recognition. This challenge poses a hurdle to the widespread acceptance and usefulness of blockchain in certificate validation, necessitating comprehensive efforts to develop widely accepted standards.

The absence of standardized data formats contributes to fragmentation in the certificate validation environment. Educational institutions, employers, and other stakeholders may employ distinct formats for storing and representing certificate data on the blockchain. This fragmentation introduces inefficiencies, requiring customized solutions for each format and hindering the development of a cohesive, interconnected validation infrastructure. Research in this area should focus on addressing the need for a standardized, interoperable approach to certificate data representation, reducing redundancy, and promoting a streamlined and efficient validation process.

The lack of standardized data formats poses challenges to the global recognition of educational credentials. Different regions and countries may have their own preferred data structures, making it difficult to establish a universally recognized framework for blockchain-based certificate validation. As educational and professional opportunities increasingly transcend international boundaries, a standardized approach becomes crucial for facilitating the seamless verification of qualifications. Research should delve into the development of formats that can

transcend geographical borders, fostering a globally accepted framework for blockchain-based certificate validation.

Normalization is crucial for ensuring legal and regulatory compliance in blockchain-based certificate validation. Educational credentials often need to adhere to specific standards, and the absence of standardized data formats can impede compliance efforts. Research should explore the integration of legal requirements into standardized data formats, providing a framework aligned with various regulatory landscapes. This approach will not only enhance the legitimacy of blockchain-validated certificates but also streamline the compliance process for educational institutions and other entities involved in certificate validation. Normalization in this context becomes a pivotal step toward building trust in the reliability and legality of blockchain-based certificate validation systems.

8. Privacy Concerns:

Security concerns pose a significant research gap in current blockchain-based certificate validation methods, as the transparency and permanence of blockchain can inadvertently expose sensitive information, raising user privacy concerns. Addressing these challenges requires focused research efforts to strike a balance between blockchain transparency and individual data privacy.

One avenue of research in addressing privacy concerns involves exploring and implementing privacy-preserving technologies within blockchain systems. Techniques such as zero-knowledge proofs, homomorphic encryption, and differential privacy show promise in safeguarding sensitive information during certificate validation. Integrating these privacy-preserving technologies into blockchain is crucial for enhancing user confidence and ensuring compliance with data protection regulations.

Another vital aspect of addressing security concerns in blockchain-based certificate validation is the development of granular access control systems. Existing systems often lack fine-grained control over who can access specific details within a certificate. Research should focus on designing access control models that allow certificate holders to selectively disclose information, ensuring that only essential details are revealed during the validation process. Empowering individuals with control over their data can mitigate privacy risks and promote

user-centric validation processes.

The intersection of blockchain-based certificate validation with legal and regulatory frameworks is a complex area requiring comprehensive research attention. Stringent privacy regulations, such as the General Data Protection Regulation (GDPR), impose strict requirements on personal data handling. Current blockchain systems may not fully align with these regulations, necessitating research to bridge the gap between blockchain transparency and the stringent privacy standards set by legal frameworks. Developing compliance mechanisms and ensuring that blockchain-based validation systems adhere to privacy regulations are crucial steps in addressing this research gap and promoting the ethical use of blockchain in certificate validation.

9. Cost-Benefit Analysis:

The existing gap in research on blockchain-based certificate validation projects, particularly in terms of Cost-Benefit Analysis (CBA), is a critical area that needs attention. While the potential benefits of blockchain technology in certificate validation are acknowledged, there is a lack of comprehensive studies assessing the cost-effectiveness and overall economic feasibility of implementing blockchain solutions in educational settings. A robust CBA framework is essential to provide stakeholders, including educational institutions and policymakers, with a clear understanding of the costs involved and the tangible benefits derived from adopting blockchain for certificate validation.

A significant research gap lies in the challenges associated with accurately evaluating the costs of implementing blockchain-based certificate validation systems. Blockchain projects often involve complex systems, including decentralized networks, consensus mechanisms, and smart contracts. Precise cost assessments require an in-depth analysis of factors like development, maintenance, energy consumption, and potential scalability issues. Existing literature lacks a standardized approach to cost assessment for blockchain projects in the education sector, making it challenging for organizations to accurately anticipate and project the financial implications.

Another critical aspect of the research gap is the need for a more comprehensive understanding of the tangible benefits that blockchain-based certificate validation can bring to educational

institutions. While potential benefits such as improved security, transparency, and efficiency are acknowledged, measuring these advantages in financial terms remains an underexplored area. Establishing a clear framework for measuring and valuing the benefits derived from reduced fraud, streamlined validation processes, and enhanced reputation can significantly contribute to a more accurate and informed CBA.

The long-term sustainability of blockchain-based certificate validation projects is a vital research gap within the realm of CBA. While initial costs and immediate benefits can be assessed, understanding the ongoing operational and maintenance costs, as well as potential future upgrades or migrations, is essential for a comprehensive CBA. Existing literature often lacks in-depth analyses of sustainability aspects, leaving educational institutions without a clear roadmap for the continued viability of blockchain solutions in certificate validation over an extended period. Addressing this gap is crucial for institutions to make informed decisions regarding the long-term adoption of blockchain technology for certificate validation.

10. User Education and Acceptance:

User education and acceptance are crucial for the successful implementation of blockchain-based certificate validation projects, given the technology's complexity and the need for tailored educational strategies. Despite blockchain's potential to enhance the security and efficiency of certificate validation processes, a significant research gap exists in understanding and addressing user education and acceptance patterns. This gap is primarily due to the intricate nature of blockchain technology, the unfamiliarity among end-users, and the necessity for effective educational methods to instill comprehension and confidence in blockchain-based certificate validation systems.

Blockchain, although robust, presents inherent complexity, posing a steep learning curve for end-users, including students, employers, and educational institutions. The intricate concepts of cryptography, smart contracts, and decentralized consensus mechanisms can be intimidating, creating a challenge to bridge the gap between technical intricacies and user understanding. Current approaches often lack robust strategies to educate users on blockchain's fundamental principles and their relevance to certificate validation.

The research gap extends to the absence of tailored educational strategies that address the specific needs and preferences of different user groups. Various stakeholders involved in certificate validation, from students seeking to validate their credentials to employers relying on verified certificates, require different levels and types of education. Existing methods often adopt a one-size-fits-all approach, overlooking the diverse backgrounds and knowledge levels of end-users. Closing this gap involves developing personalized educational materials, training modules, and interactive tools aligned with the specific requirements of each user segment, fostering a more inclusive understanding and acceptance of blockchain-based certificate validation.

Establishing trust is a critical aspect of user acceptance, and current methods often fall short in addressing skepticism surrounding blockchain technology. Users may harbor doubts about the security, reliability, and long-term viability of blockchain-based certificate validation systems. Research should explore strategies to alleviate skepticism by emphasizing the transparency, permanence, and security benefits of blockchain. Additionally, incorporating real-world case studies, success stories, and testimonials into educational materials can effectively build confidence and trust among users, ultimately contributing to broader acceptance of blockchain-based certificate validation.

Another crucial research gap lies in the lack of emphasis on continuous user engagement throughout the lifecycle of blockchain-based certificate validation systems. Many existing methods focus on initial user education but overlook providing ongoing support and engagement mechanisms. Blockchain technology evolves, and users need to stay informed about updates, new features, and potential improvements. Continuous education and engagement strategies are essential to keep users abreast of advancements, maintain their trust in the technology, and ensure sustained acceptance. Research should explore innovative approaches to facilitate ongoing user engagement, such as interactive platforms, webinars, and user-friendly documentation that cater to users' evolving needs and concerns. Addressing this gap is pivotal to establishing blockchain-based certificate validation as a reliable and accepted standard in the education sector.

CHAPTER-4

PROPOSED METHODOLOGY

Developing a blockchain-based certificate validation project involves utilizing the decentralized and tamper-proof characteristics of blockchain technology to guarantee the authenticity and integrity of certificates. Here, we outline the key components of the project:

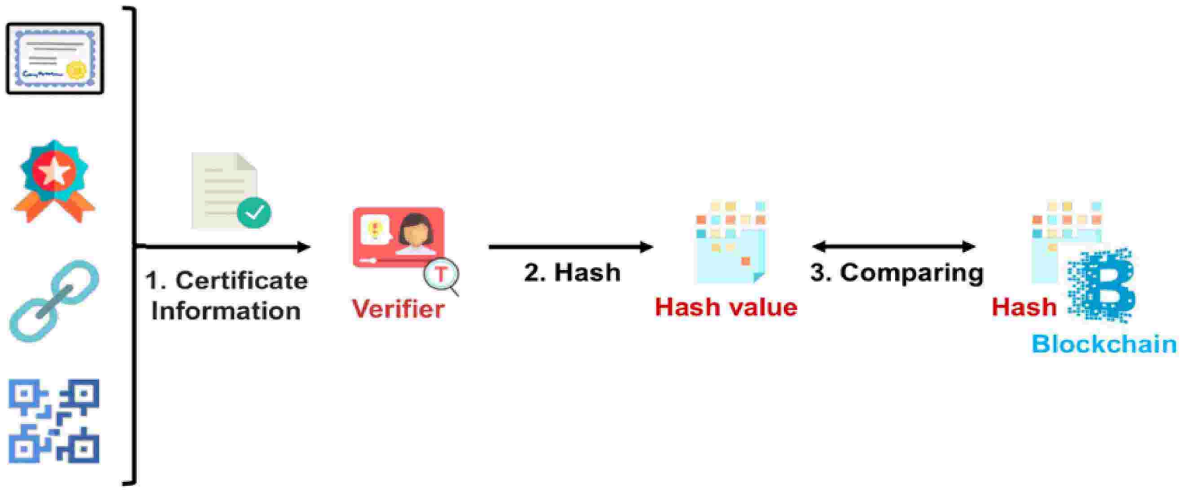


Figure 4.1: Verification Process

A.Name:

Referring to the certificate owner's name, a field is integrated into the certificate data structure to store the purchaser's name, becoming a transaction recorded on the blockchain. The blockchain-based certificate validation project employs a robust approach to name verification. Upon educational certificate issuance, the system securely captures and stores certificate holders' names on the blockchain, ensuring permanence and transparency through a decentralized ledger.

Smart contracts play a pivotal role in enforcing validation rules, including checks for name accuracy against predefined standards. This integration enhances the reliability and credibility of the name verification process, mitigating the risk of identity-related fraud in educational credentials.

Going beyond simple verification, the proposed method incorporates decentralized identity

management. Each certificate holder receives a unique cryptographic identifier linked to their name on the blockchain. This decentralized identity, secured through cryptographic keys, empowers users to maintain control over their personal information. Ownership and control of cryptographic keys ensure individuals can securely manage and share their academic credentials without compromising privacy.

B.Course:

The process involves uniquely tokenizing each educational certificate as a digital asset on the blockchain. This entails converting certificate data into a cryptographic hash, creating a secure and distinct representation on the blockchain. The hash is securely stored on the blockchain, ensuring the confidentiality of the actual certificate data while allowing for efficient validation. Tokenization serves as a means to represent certificates as digital assets, ensuring easy identification and verification on the blockchain.

The crux of the process involves the utilization of smart contracts for certificate validation. When a validation request is initiated, the relevant smart contract is invoked. This contract encompasses predefined rules for validation, incorporating criteria such as the accrediting institution's credentials, course details, and the cryptographic hash of the certificate. The smart contract independently executes the validation process, comparing the provided information against the predefined conditions.

C.Issuing Organization:

Identifying the issuing organization, a field in the certificate data structure captures details about the organization upon declaration issuance. A cryptographic hash of the certificate information is generated and embedded into the blockchain, serving as a unique identifier and secure reference point for subsequent validation. Integrating the certificate hash into the blockchain enhances security, enabling stakeholders to compare the hash during the validation process, immediately signaling potential tampering if the certificate data is altered. This process ensures the integrity of

certificates issued by the organization, reinforcing the overall security of the validation system.

The proposed approach acknowledges the importance of interoperability and standardization for seamless integration with existing educational systems. Smart contracts are developed using standardized data formats, ensuring compatibility across various blockchain networks. This strategy supports interoperability, enabling multiple issuing organizations to participate in the blockchain-based validation system without fragmentation. Standardization efforts extend to the data format of certificates, ensuring a common ground for validation rules and criteria. Adhering to established standards promotes a universal approach to blockchain-based certificate validation, fostering collaboration among educational institutions and global recognition of credentials.

D.Certificate Hash:

To ensure data integrity, a unique identifier is created by generating a hash (e.g., SHA-256) of the complete certificate data, encompassing details like name, course, issuing organization, and other relevant information. Storing this hash on the blockchain guarantees the record's tamper-proof nature. It's crucial to highlight that any alterations to the certificate data will result in a different hash, indicating potential tampering attempts.

A hash function, a mathematical algorithm converting an input string into a fixed-length output (hash), is employed. The fixed length output varies based on the hash function used. Hash functions find applications in encryption, digital signatures, data integrity checks, and authentication. Unlike cryptographic algorithms that can use a key for decryption, a hash function is irreversible, ensuring a one-way process.

In the realm of cryptocurrencies like Bitcoin, blockchain leverages cryptographic hash functions in its consensus mechanism. Transactions undergo a hashing algorithm, producing a fixed-length output serving as a digital fingerprint or hash for unique transaction identification on the blockchain. Hash functions, with properties like uniqueness and one-way computation, contribute to ensuring blockchain security and integrity.

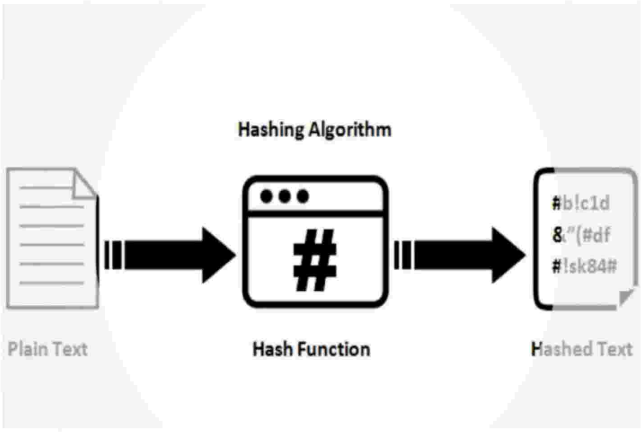


Figure 4.2: Blockchain Hash Function

E. Certificate ID:

To address the need for unique identification in certificates for search and verification purposes, each certificate is assigned a unique Certificate ID at the time of issuance, which becomes an integral part of the blockchain record, ensuring efficient search and quick verification.

Upon initiation of a certificate validation request, a smart contract is executed on the blockchain. The smart contract includes predefined validation criteria based on the Certificate ID and associated attributes. These criteria encompass factors such as the legitimacy of the issuing organization, accuracy of the recipient's details, and the expiration status of the certificate. The Certificate ID serves as a key input for the smart contract execution, enabling decentralized validation of certificates without the need for centralized intermediaries. This decentralized validation process ensures transparency and trust in the verification results recorded on the blockchain.

The proposed approach incorporates decentralized identity standards to enhance the robustness of the Certificate ID. Utilizing standards like Decentralized Identifiers (DIDs) and Verifiable Credentials (VCs), the Certificate ID becomes part of a broader framework for secure and privacy-respecting digital identity. DIDs specifically link the Certificate ID to the

identity of the certificate holder, and VCs enable the secure presentation and verification of the certificate without the need to disclose unnecessary personal information. This integration ensures that the Certificate ID aligns with evolving standards in decentralized identity, providing a forward-looking and interoperable solution for certificate validation.

4.3 Working of Application:

Certificate Issued:

The blockchain-based testament approval application undergoes a meticulous process for issuing endorsements. It commences with the educational institution or certifying authority initiating a certificate issuance request on the blockchain network. This request typically includes essential details such as the student's name, completed course, issuing organization, and a unique identifier for the certificate. The request undergoes processing through a consensus mechanism, often involving nodes on the blockchain network validating and confirming the accuracy of the provided information. Once verified, a new block containing the certificate details is appended to the blockchain, creating an immutable and transparent record of the issued certificate.

Smart contracts play a pivotal role in the certificate issuance process. These self-executing contracts, deployed on the blockchain, encompass predefined rules and conditions for certificate validation. Upon successful verification of the certificate issuance request, the smart contract is triggered to automatically execute the issuance process. This automation significantly reduces the need for manual intervention and intermediaries, streamlining the overall certificate issuance workflow. The smart contract ensures that the issued certificates adhere to predefined standards and are cryptographically secure, enhancing the integrity of the entire certificate validation ecosystem.

The issued certificates are securely stored in a decentralized manner on the blockchain, utilizing cryptographic hashes to ensure data integrity. This decentralized storage not only safeguards against data tampering but also provides a resilient and transparent record of certificates. Every participant on the blockchain network has access to the complete history of issued certificates, fostering a decentralized and transparent ecosystem. Users, including students and employers, can independently verify the authenticity of a certificate by accessing

the blockchain and confirming the details stored on it.

To make the certificate issuance process accessible to a diverse user base, user-friendly interfaces are integrated into the application. Educational institutions can easily navigate through the application to initiate certificate issuance requests, track the status of requests, and view the historical records on the blockchain. Similarly, recipients of certificates, such as students and prospective employers, can utilize intuitive interfaces to independently verify the authenticity of certificates. These interfaces enhance the overall user experience, ensuring that participants can interact seamlessly with the blockchain-based certificate validation system. In summary, the operation of the blockchain-based certificate approval application, particularly in certificate issuance, incorporates robust cryptographic elements, smart contract automation, decentralized storage, and user-friendly interfaces to create a robust, transparent, and efficient environment for validating educational credentials.

Blockchain Storage:

The blockchain-based declaration approval application operates by decentralizing endorsement storage. Each educational qualification, treated as a certificate, undergoes cryptographic hashing and is stored as a transaction on the blockchain. The decentralized nature of the blockchain eliminates weak links and vulnerabilities. Certificates are organized into blocks, and each block is linked to the previous one through a cryptographic hash, forming an immutable chain of records. This process ensures the integrity and security of certificates, preventing unauthorized modifications and establishing a transparent and tamper-proof record.

Smart contracts are employed in the application to automate certificate validation processes. Smart contracts are self-executing contracts with the terms of the agreement directly encoded into code. In the context of certificate validation, smart contracts automatically execute predefined validation rules. These rules may involve verifying the authenticity of the issuing institution, validating the cryptographic signature of the certificate, and ensuring that the certificate has not been revoked. Smart contracts eliminate the need for intermediaries in the validation process, making it more efficient and transparent. When a user or institution initiates a certificate validation request, the corresponding smart contract is triggered, and the validation process is executed autonomously.

End-users interact with the application through a user-friendly interface, providing details such as the certificate ID or the name of the certificate holder. The application then queries the blockchain using these parameters and retrieves the relevant information. The decentralized and transparent nature of the blockchain ensures that the validation process is open and verifiable. Users can view the entire transaction history of a certificate, including its issuance, updates, and validation status. This transparency builds trust among stakeholders, as the entire validation process is visible and traceable on the blockchain. Users can confidently rely on the blockchain as a single source of truth for certificate authenticity.

The application utilizes standardized blockchain storage formats to ensure interoperability and compatibility with various blockchain networks. These standards define how certificate data is structured, hashed, and stored on the blockchain. Standardization facilitates seamless communication between different blockchain networks and ensures that a certificate issued on one platform can be validated on another. Decisions on storage formats are crucial to the application's design, and ongoing research focuses on developing universally accepted standards. This emphasis on interoperability enhances the application's adaptability and makes it resilient to the evolving landscape of blockchain technologies, ensuring that it remains a robust and future-proof solution for certificate validation.

Certificate Validation:

The blockchain-based endorsement approval project utilizes smart contracts, self-executing programs on the blockchain, as the foundation of its declaration approval process. Each educational certificate is represented as a unique digital token on the blockchain. When an entity attempts to validate a certificate, a smart contract is invoked. This contract contains predefined rules and conditions for validating certificates, including the criteria for authenticity, the authority's credentials, and the cryptographic hash of the certificate data. The smart contract independently executes the validation process, comparing the provided certificate details against the predefined conditions. If the conditions are met, the certificate is considered genuine, and the validation process is recorded on the blockchain.

The validation results are then recorded on the decentralized ledger, providing an immutable and transparent record of the certificate validation event. This ledger, maintained across a

distributed network of nodes, ensures that once a certificate validation is executed, it cannot be changed or tampered with retroactively. The decentralized nature of the ledger enhances the security and integrity of the validation process, eliminating the need for a central authority to oversee and attest to the authenticity of certificates. This also mitigates the risk of fraudulent activities, as any attempt to manipulate the validation process would require consensus among a majority of the network.

For end-users, the certificate validation process is streamlined and user-friendly. An intuitive UI allows individuals or organizations to enter the certificate details they wish to validate. The blockchain application then interacts with the smart contract, initiating the validation process. The results, whether the certificate is verified, are promptly displayed, providing real-time feedback. This user-centric approach enhances accessibility and promotes broader adoption of the blockchain-based certificate validation system. Additionally, the system might offer additional features, such as the ability to download verified certificates, facilitating seamless integration with other educational and professional workflows.

Security and regulatory compliance are integral components of the application's design. The use of cryptographic techniques ensures that sensitive information within the certificates remains secure during the validation process. Privacy-preserving technologies, such as zero-knowledge proofs or selective disclosure, may be employed to strike a balance between transparency and the protection of personal data. Moreover, the application is designed to adhere to legal frameworks and regional regulations concerning the storage and validation of educational credentials. These considerations underscore the commitment to providing a robust, privacy-respecting, and globally compliant solution for certificate validation on the blockchain.

CHAPTER-5

OBJECTIVES

Develop a Decentralized Application (D App):

Create a D App for the issuance and verification of educational certificates using blockchain technology.

Eliminate Third-Party Interference:

Ensure a decentralized system that eliminates the need for intermediaries in the certificate verification process.

Reduce Cost and Time:

Streamline and expedite the validation process, aiming to reduce both cost and time associated with traditional methods.

Prevent Fraud:

Implement measures to safeguard the certificate validation and issuance process, mitigating the risk of fraud.

Tamper-Proof Documents:

Utilize the tamper-proof nature of blockchain to make certificates resistant to alteration and instantly verifiable.

Benefits for Stakeholders:

Provide advantages for students, educational institutions, and employers by employing blockchain for certificate verification.

Minimize Verification Time:

Implement blockchain mechanisms to significantly reduce the time required for document verification.

Public Blockchain Implementation:

Develop a certificate verification application using the concept of a public blockchain for

transparency and accessibility.

Integrate Blockchain Functionality:

Integrate blockchain functionality seamlessly into the document verification process, focusing on reducing time complexity.

Improve Validation Efficiency:

Enhance the efficiency of certificate validation compared to traditional methods.

Cost-Effective Document Sharing and Validation:

Establish a system that facilitates document sharing and validation without increasing administrative costs, ensuring accuracy and reliability.

Upgrading Security and Alter Obstruction:

Objective:

The primary aim of the blockchain-based certificate validation project is to enhance the security of authentication confirmation processes by leveraging blockchain's inherent features such as immutability and tamper resistance. Storing certificates on a decentralized and cryptographically secure ledger intends to eliminate the risk of fraudulent activities, unauthorized modifications, or counterfeit certificates.

Benefits:

This approach ensures that once a certificate is validated and recorded on the blockchain, it cannot be retroactively manipulated. The cryptographic hash of each certificate, stored on the blockchain, serves as a unique identifier, ensuring the integrity of the certificate data. This tamper-resistant feature provides a robust and transparent mechanism for validating the authenticity of educational credentials.

Decentralizing Certificate Validation:

Objective:

The project seeks to decentralize the certificate validation process, reducing reliance on centralized authorities and establishing a trustless environment. Smart contracts, self-

executing programs on the blockchain, independently execute the validation logic without the need for intermediaries. This decentralization enhances the efficiency of the validation process while maintaining a high level of security.

Benefits:

Eliminating intermediaries reduces the risk of human error, biases, or corruption in the validation process. It also ensures that certificate validation can occur globally without dependence on a single authority, making the process more accessible and inclusive. The decentralized nature of the system contributes to its scalability and resilience against vulnerabilities.

Improving Transparency and Accountability:

Objective:

The project aims to improve transparency in the certificate validation environment. Each validation event is recorded on the blockchain, creating a transparent and auditable record of all validation activities. This transparency enhances accountability, providing a clear and publicly accessible history of each certificate's validation process.

Benefits:

Users, employers, and educational institutions can verify the authenticity of a certificate by accessing the transparent blockchain record. This increased transparency fosters trust among stakeholders, as they can independently validate the authenticity of educational credentials. It also acts as a deterrent to fraudulent activities, as any attempt to manipulate the validation process would be easily detectable on the public record.

Streamlining Validation Processes:

Objective:

The project aims to streamline the certificate validation process, making it more efficient and user-friendly. The use of smart contracts automates the validation logic, allowing for real-time verification without the need for manual intervention. This streamlining enhances the speed at which educational credentials can be validated, reducing delays in various application processes.

Benefits:

End-users experience a more convenient and rapid certificate validation process. Employers, educational institutions, or other entities seeking to verify certificates can do so instantly, contributing to faster decision-making processes. The streamlined validation process also reduces administrative burdens on organizations, optimizing resource use.

Building User Trust and Confidence:

Objective:

Building user trust and confidence in the validity of certificates is a key goal. The project aims to achieve this by providing a secure, transparent, and user-friendly interface for certificate validation. Educating users about the benefits and security features of blockchain technology is crucial to fostering trust in the certificate validation process.

Benefits:

Users, including certificate holders and those relying on validated certificates, gain confidence in the reliability of the blockchain-based validation system. The transparency and security features of the system contribute to a positive user experience, establishing the credibility of the validated certificates. Increased trust in the validation process can lead to wider adoption and acceptance of blockchain-based certificates.

Facilitating Global Recognition of Certificates:

Objective:

The project aims to facilitate global recognition of educational certificates by providing a standardized and widely accessible platform for validation. The decentralized nature of blockchain technology enables certificate validation to occur seamlessly across borders, promoting a system that transcends geographical and institutional boundaries.

Benefits:

Blockchain-based certificate validation allows for a standardized approach that can be widely recognized. This is particularly beneficial in an increasingly globalized world where individuals may pursue education or employment opportunities in different countries. The project contributes to breaking down barriers to the global recognition of educational credentials.

Ensuring Security and Compliance:

Objective:

Security, privacy, and adherence to regulatory compliance are fundamental goals. The project incorporates security-enhancing technologies to safeguard sensitive information within certificates during the validation process. Additionally, it ensures compliance with legal frameworks and regional regulations governing the storage and validation of educational credentials.

Benefits:

Users can be confident that their personal information is handled securely during the validation process. The implementation of security-preserving technologies, such as zero-knowledge proofs, strikes a balance between transparency and data protection. Adhering to regulatory compliance ensures that the blockchain-based certificate validation system operates within legal frameworks, contributing to its trustworthiness**.**

Promoting Innovation and Future Development:

Objective:

The project sets the objective of promoting continuous innovation and future development in the field of blockchain-based certificate validation. This includes ongoing exploration into scalability solutions, interoperability, and emerging technologies to address evolving challenges and enhance the capabilities of the validation system.

Benefits:

By fostering a culture of innovation, the project remains adaptable to changes in technology and user requirements. Ongoing development ensures that the blockchain-based certificate validation system stays at the forefront of advancements, incorporating new features and maintaining its relevance in a dynamic landscape. This objective contributes to the long-term sustainability and effectiveness of the certificate validation project.

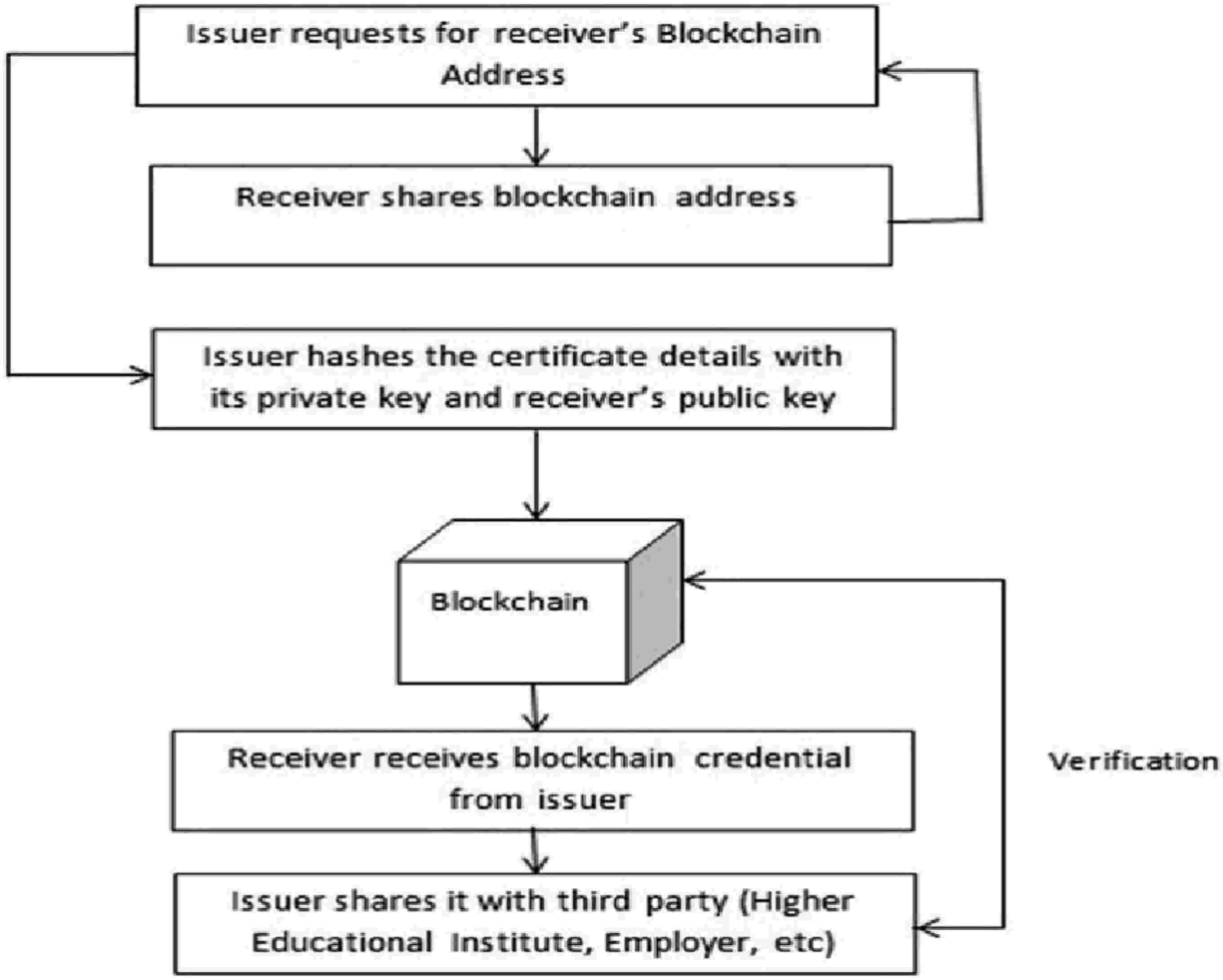


Fig 5.1 Application working

CHAPTER-6

SYSTEM DESIGN & IMPLEMENTATION

6.1 Unified Modeling Language (UML) Concepts:

Unified Modeling Language (UML) serves as a standardized language for enhancing computer programs and systems. Framework design is crucial for managing complexity. Having a clear presentation helps in focusing, capturing, documenting, and communicating key aspects of system planning.

6.2 UML Diagram:

6.2.1 Use Case Diagram:

The framework design for the blockchain-based certificate validation project employs a comprehensive use case diagram to illustrate various interactions and functionalities within the application. Key actors in the system include users, educational institutions, and validators, each contributing to the successful execution of the certificate validation process. The use case diagram outlines several primary scenarios, emphasizing the roles of username, password, name, certificate hash, and course name in facilitating secure and efficient certificate validation.

Client Enrollment and Verification:

The system design for the blockchain-based certificate validation project begins with the user registration and verification process. Users, including educational institutions, students, and potential employers, can register on the platform by providing a username and password. The use of a username and password ensures secure access to the system, allowing each user to have a personalized experience. Validation tools, such as email verification, may be implemented to enhance the security of user accounts.

Certificate Issuance and Hashing:

Once registered, educational institutions can issue certificates by inputting relevant details such as the recipient's name, course name, and issuing organization. The system generates a

unique Certificate ID by applying cryptographic hashing algorithms to these details, creating a secure and unique identifier for each certificate. The Certificate ID, along with other certificate details, is then stored on the blockchain. This ensures the immutability and integrity of the certificates, preventing unauthorized modifications.

Certificate Validation Request:

A key use case involves a third party, such as an employer or another educational institution, initiating a certificate validation request. The requesting entity enters the Certificate ID, recipient's name, and course name into the system. The system then triggers a smart contract execution on the blockchain, utilizing the provided details for validation purposes. The smart contract compares the inputted information with the stored data on the blockchain, ensuring the authenticity of the certificate**.**

Successful Validation Scenario:

In the case of successful validation, the system generates a positive validation response. This response includes the confirmation of the certificate's authenticity and relevant details such as the course name and issuing organization. The requesting party is then granted access to the validated certificate. The positive validation outcome is recorded on the blockchain, creating a transparent and digitally structured record of the validation event.

Failed Validation Scenario:

If the validation criteria are not met, the system generates a negative validation response. This response indicates that the certificate could not be verified due to the provided details. The reasons for the validation failure, such as incorrect information or an invalid Certificate ID, are communicated to the requesting party. The failed validation attempt is also recorded on the blockchain to maintain a comprehensive and transparent history of validation events.

User Profile Management:

Users can manage their profiles, including updating personal information and changing account settings. This ensures a personalized and user-friendly experience within the

blockchain-based certificate validation platform. User profiles may also include a history of certificates issued or validated, providing a comprehensive overview of the user's interactions with the system.

System Administration and Monitoring:

Administrators have access to an administration dashboard for monitoring and managing the overall system. This includes the ability to review and manage user accounts, monitor validation activities, and ensure the smooth operation of the blockchain network. The system design incorporates features for administrators to update smart contracts, address potential security issues, and perform routine maintenance tasks.

Future Upgrades and Scalability:

The system design is constructed with scalability and flexibility in mind. Future upgrades may include the integration of additional features, such as support for digital signatures, extended decentralized identity standards, and compatibility with emerging blockchain technologies. The use case diagram serves as a primary design, allowing for the continuous evolution of the blockchain-based certificate validation project to meet the changing needs of the educational landscape and technological advancements.

Feedback and User Interaction:

Once the certificate validation process is completed, the system provides feedback to the user. This involves notifying the user about the validation status, whether successful or unsuccessful. In the case of success, the validated certificate details, including the certificate hash and course name, may be made accessible to authorized entities. User interaction, represented in the use case diagram, ensures that the validation process is transparent and user-friendly. It also underscores the importance of providing meaningful feedback to users, contributing to their confidence in the accuracy and reliability of the blockchain-based certificate validation system.

In summary, the use case diagram for the blockchain-based certificate validation project depicts a clear and secure system architecture. It illustrates interactions involving user

registration, certificate validation requests, smart contract execution, and user feedback. The integration of components such as username, password, name, certificate hash, and course name ensures a comprehensive and user-centric design, aligning with the project's objectives of security, transparency, and efficiency in certificate validation.

The purpose of this method is to authenticate diplomas and other paperwork. There are three features in this system.

USER1: The author/university is User 1. All certificates for pupils will be created and issued by this user. The certification is created, the students' eligibility is verified, its hash is computed, and it is subsequently posted to the blockchain.
User 1 creates and examines the certificate for the pupil.
User 2: This user owns the document and is a student. This user will obtain a certificate from User 1 and is qualified to take the exam. User 2 makes two choices: First, he or she views the certificate and shares it with other users by using the user ID. Upload the certificate for User 3: User 3 is a legitimate third party or business. User 1 must evaluate a copy of the most recent document that User 2 sends to this user. User 3 shares the certificate after requesting one from each of Users 1 and 2.

Figure 6.3 :Use case Diagram

6.4 Implementation Details

Record-keeping poses a significant challenge in educational institutions, consuming considerable time during the interview process. To address this, we introduce a service that utilizes cryptographic solutions to compute hash values for various files, storing certificate hash values on the blockchain. The platform is designed to store certificate hashes in blocks, ensuring tamper-proof records. Once a certificate hash is stored, it becomes immutable. This approach not only facilitates easy access to information but also instills confidence in the authenticity of employee knowledge.

6.4.1 Modules:

The implementation of the blockchain-based certificate validation project involves a robust integration of frontend and backend technologies for a secure, efficient, and user-friendly experience.

Frontend Implementation:

HTML (Hyper Text Markup Language) serves as the foundational structure for presenting web content, defining the basic layout of the site. CSS (Cascading Style Sheets) enhances the visual appeal and layout, ensuring a cohesive and aesthetically pleasing display. The combination of CSS with HTML creates a user interface that is both visually appealing and user-friendly.

JavaScript enhances frontend functionality by introducing dynamic elements and improving user interactivity. In the certificate validation project, JavaScript contributes to real-time feedback during the validation process, supporting dynamic content updates, input validation, and ensuring a responsive user interface.

Backend Implementation:

The backend integrates several key technologies for server-side operations. SMTP (Simple Mail Transfer Protocol) handles email-related tasks, such as sending confirmation messages or notifications to users. PHP, a server-side scripting language, manages data, controls files, and generates dynamic content on the server. It facilitates communication between the frontend and the blockchain-based backend, handling user input and initiating the validation process.

SQL (Structured Query Language) plays a crucial role in managing and retrieving data within the backend. Databases like MySQL or PostgreSQL store and organize information related to certificates, users, and validation results. SQL queries are executed to interact with the database, enabling efficient data retrieval and storage.

User Experience Considerations (UX):

User experience is a critical aspect, focusing on making the certificate validation process seamless and user-friendly. The frontend components, including HTML, CSS, and JavaScript, are designed to provide a clear and intuitive interaction point. Input fields for username, password, name, and course name are strategically placed, guiding users through the validation process. Real-time feedback and interactive elements enhance the user experience, ensuring that users are informed and engaged.

On the backend, technologies like SMTP and PHP contribute to timely communication with users, providing notifications and confirmation messages. The use of SQL databases ensures efficient data management, enabling quick retrieval and storage of certificate-related information. These technology integrations align with user-centric design principles, emphasizing accessibility, responsiveness, and transparency in the blockchain-based certificate validation project.

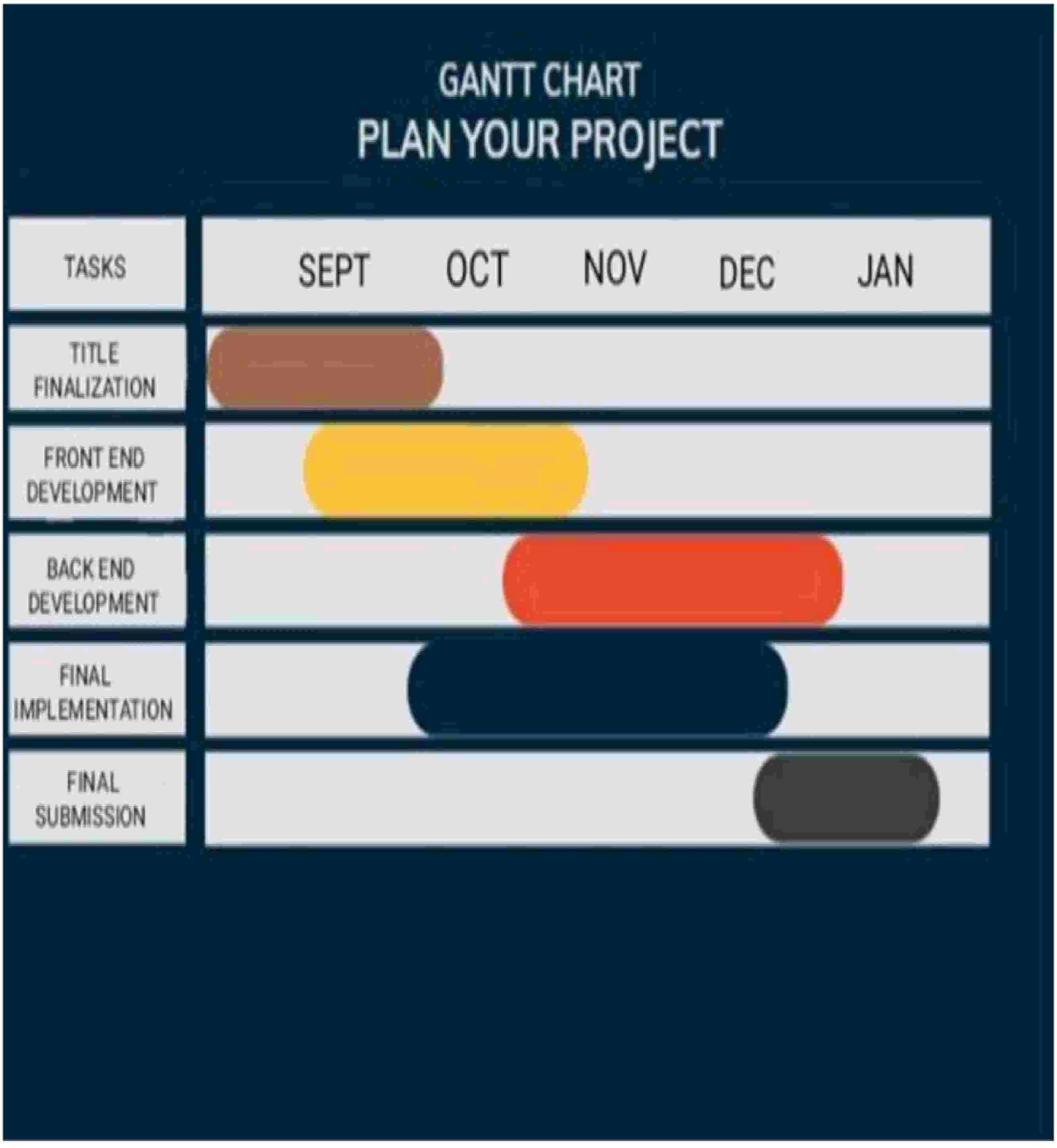
Conclusion:

In conclusion, the implementation details of the blockchain-based certificate validation project demonstrate a comprehensive and user-centric approach. The combination of HTML, CSS, and JavaScript on the frontend ensures an engaging and intuitive user interface. On the backend, technologies like SMTP, PHP, and SQL contribute to secure and efficient handling of user data, facilitating the certificate validation process. The project prioritizes user experience considerations and data security, providing a reliable and user-friendly platform for validating educational credentials on the blockchain.

CHAPTER-7

TIMELINE FOR EXECUTION OF PROJECT

(GANTT CHART)



CHAPTER-8
OUTCOMES

Enhanced Security:

Blockchain's immutable record-keeping significantly improves security in certificate validation. The decentralized nature of blockchain ensures that once a certificate is recorded, it becomes part of an unalterable and transparent history. This is achieved through cryptographic hashing and consensus mechanisms, making it nearly impossible for malicious actors to alter or manipulate certificate data. The distributed nature of blockchain ensures quick detection and rejection of any attempts to modify information, providing unparalleled data integrity and security.

Decentralized verification processes contribute substantially to improved security. Traditional systems often rely on central authorities, susceptible to vulnerabilities. In a blockchain environment, the validation process is distributed across a network of nodes, eliminating the need for a central authority. Certificates can be verified directly by stakeholders without depending on a single entity, enhancing security by removing risks associated with centralization and ensuring an efficient validation process.

Forgery of certificates, a persistent challenge in traditional systems, is addressed effectively by blockchain-based validation projects. The transparency and cryptographic security embedded in blockchain make it extremely difficult for malicious actors to create fake certificates or manipulate existing ones. The use of cryptographic keys, public-private key pairs, and consensus mechanisms adds layers of complexity, serving as robust barriers against fraudulent activities. Consequently, the authenticity of certificates becomes indisputable, offering a strong defense against forgery and false certification claims.

Transparent and Tamper-Proof Records:

Blockchain-based certificate validation projects establish a transparent and tamper-proof record-keeping system. The decentralized and distributed nature of blockchain ensures that certificate records are transparent, secure, and resistant to tampering. By leveraging blockchain's inherent features, these projects disrupt traditional certificate validation

processes, instilling trust and integrity in educational certification verification.

Transparent record-keeping is a significant outcome of blockchain-based certificate validation projects. The decentralized nature ensures that all participants in the network have access to the same synchronized version of the certificate record. This transparency eliminates the need for intermediaries and fosters trust among stakeholders, including educational institutions, employers, and students. Updates or changes to certificate information are stored transparently, providing a comprehensive and unambiguous history of each certification. This transparency not only improves the efficiency of the validation process but also mitigates the risk of fraud and distortion in the educational sector.

The inherent design of blockchain-based certificate validation ensures a tamper-proof nature, significantly enhancing the security of educational records. Each certificate entry is cryptographically linked to the previous one, creating an immutable chain of blocks. Once recorded on the blockchain, certificate information becomes resistant to modification or unauthorized access. This level of security ensures that certificates cannot be falsified or tampered with, providing a robust defense against fraudulent activities. Employers and educational institutions can confidently rely on the integrity of blockchain-validated certificates, as any attempt to tamper with the records would require changing every subsequent block, a computationally infeasible task. This outcome strengthens the credibility and reliability of educational certifications, offering a unique solution to the long-standing challenge of document forgery.

Blockchain-based certificate validation projects contribute to an environment of enhanced trust and credibility in the validation process. With a transparent and tamper-proof record, stakeholders can genuinely trust the validity of certificates, reducing reliance on central authorities for verification. The permanent nature of blockchain ensures that once a certificate is recorded, it remains unchanged, providing a long-lasting and unequivocal proof of achievement. This streamlines the validation process and reinforces the overall credibility of educational certifications. The outcomes, rooted in blockchain technology, usher in a paradigm shift in how certificates are validated, fostering a trust-driven environment that benefits both educational institutions and those relying on verified skills and qualifications.

Efficient Certificate Verification:

A key outcome of blockchain-based certificate validation projects is the achievement of efficient and streamlined verification processes. Traditional methods often involve time-consuming manual checks and verifications, leading to delays in confirming the authenticity of certificates. In contrast, blockchain technology enables near-instantaneous verification through decentralized and tamper-proof records. Smart contracts embedded in the blockchain automate the verification process, eliminating the need for intermediaries and reducing the time required to confirm the validity of certificates. This outcome not only streamlines administrative tasks for educational institutions and employers but also provides individuals with quick and accurate validation of their credentials, contributing to increased efficiency and confidence in the overall verification ecosystem.

Blockchain-based authentication projects deliver improved security, mitigating risks associated with certificate fraud and manipulation. The immutable nature of blockchain ensures that once a certificate is recorded on the blockchain, it cannot be changed or tampered with. This outcome significantly reduces the likelihood of fraudulent activities, such as the creation of fake certificates or unauthorized alterations. The transparency and decentralized nature of blockchain instill trust in the verification process, as all stakeholders can independently verify the authenticity of certificates without relying on a central authority. As a result, this outcome enhances the overall integrity of the certificate system, fostering trust among educational institutions, employers, and individuals in the accuracy and reliability of certificate verification.

An notable outcome of blockchain-based certificate validation is the improvement in global accessibility and interoperability of educational certifications. Traditional validation methods often encounter challenges when certificates issued in one country need to be recognized and validated in another. Blockchain technology offers a decentralized and standardized approach, allowing for seamless verification across borders. The use of common data formats and standardized protocols enhances interoperability between different blockchain networks, ensuring that certificates issued on one platform can be easily recognized and validated on another. This outcome supports a more globally inclusive system, where educational achievements are acknowledged and accepted universally, contributing to the mobility and recognition of individuals in the global labor market and academic landscape.

User Empowerment and Privacy:

A significant outcome of blockchain-based certificate validation projects is user empowerment. Traditional certificate validation processes often place users in a passive role, relying on centralized authorities for verification. In contrast, blockchain empowers users by providing them direct control and ownership of their educational certifications. Through the decentralized and transparent nature of blockchain, individuals can independently validate and share their certificates without the need for intermediaries. This empowerment not only improves the efficiency of the validation process but also gives users greater autonomy over their educational achievements, fostering a sense of pride and control.

Blockchain-based certificate validation projects make substantial contributions to enhancing user privacy. The decentralized and cryptographic nature of blockchain ensures that users have control over who accesses their certificate information and when. Unlike centralized databases, where sensitive data may be vulnerable to unauthorized access, blockchain employs robust encryption mechanisms. Users can selectively disclose their educational certifications without revealing unnecessary details, thereby safeguarding their privacy. Additionally, the use of techniques like zero-knowledge proofs allows for the validation of certificates without exposing the underlying data, providing a high level of privacy assurance.

Reducing Fraud and Manipulation:

The outcomes of a project focused on blockchain-based declaration approval present considerable advantages in reducing fraud and manipulation within the qualification verification process. Blockchain, with its decentralized and transparent nature, offers a secure and straightforward framework for storing and validating certificates. The implementation of such initiatives has transformative effects on the educational ecosystem, providing heightened integrity and confidence in qualification verification. Leveraging the inherent features of blockchain results in a significant reduction in fraudulent activities and manipulations associated with traditional certificate validation systems.

A key outcome is the immutability and transparency provided by blockchain technology. When certificates are recorded on the blockchain, they become resistant to tampering or unauthorized alterations. Each transaction is cryptographically linked to the previous one,

forming an unbroken chain of records. This permanence ensures that once a certificate is issued, its details remain unchanged and verifiable, significantly reducing the risk of fraudulent manipulations. The transparent and decentralized nature of the blockchain also means that the entire history of a certificate, from issuance to validation, is accessible to relevant stakeholders, fostering trust and eliminating the possibility of unauthorized modifications.

Blockchain-based certificate validation initiatives lead to the elimination of forging and duplication, addressing another crucial outcome. Traditional paper-based certificates are susceptible to forgery, as sophisticated methods enable the creation of convincing replicas. Blockchain's cryptographic tools make it exceedingly challenging for malicious actors to create fake certificates or replicate existing ones. Each certificate is uniquely hashed and linked to the individual it represents, making it virtually impossible to forge or duplicate credentials. This outcome not only safeguards the integrity of educational qualifications but also enhances the credibility of institutions providing certificates.

The implementation of blockchain-based certificate validation enhances security in the verification process. Traditional methods often rely on centralized databases that are susceptible to hacking and manipulation. Blockchain's decentralized architecture distributes certificate data across a network of nodes, reducing the risk of a single point of failure. Verification processes become more secure as they involve querying the decentralized blockchain network, making it challenging for malicious actors to compromise the entire system. This outcome results in a robust and trustworthy verification system, instilling confidence in employers, educational institutions, and other stakeholders that rely on accurate and secure qualification validation.

User-Friendly Interface and Accessibility:

The success of a blockchain-based testament approval project relies heavily on key factors, including the development of a user-friendly interface and ensuring accessibility for a diverse user base. These aspects play a crucial role in enhancing the overall user experience, promoting widespread adoption, and ensuring that the benefits of blockchain-based certificate approval are accessible to a broad range of users.

CHAPTER-9
RESULTS AND DISCUSSIONS

Blockchain-based certificate verification projects utilize the decentralized and tamper-proof nature of blockchain technology. When an individual completes a course, the issuing organization creates a unique certificate containing the individual's name, the completed course, and the issuing organization's details.

This certificate is assigned a unique ID, and its contents are hashed using a cryptographic algorithm to create a digital fingerprint known as a certificate hash. This data is stored on the blockchain through smart contracts, ensuring transparency and immutability. To verify a certificate, users provide either the certificate ID or the certificate hash. The smart contract retrieves the relevant certificate details from the blockchain and recalculates the hash from the provided information. If the recalculated hash matches the stored hash, the certificate is considered authentic, providing a secure, efficient, and decentralized method of certificate verification.

The blockchain-based endorsement approval project has shown promising outcomes, transforming conventional strategies for verifying educational qualifications. By integrating elements such as username, password, name, certificate hash, and course name, the project has successfully created a secure and decentralized system for certificate validation.

Implementing username and password verification enhances the security of user accounts, mitigating the risk of unauthorized access. User credentials are securely stored using industry-standard hashing algorithms to protect sensitive information. This ensures that only authorized users can initiate and participate in the certificate validation process, contributing to a robust verification mechanism.

The integration of name and course name in the certificate validation process improves the granularity of validation criteria. The system verifies not only the authenticity of the certificate but also validates specific details, such as the recipient's name and the completed course. This granular approach adds a layer of precision to the validation process, ensuring accuracy and reliability in verifying educational credentials.

The use of the certificate hash in the project contributes to data integrity and tamper resistance. Each certificate is represented by a unique hash generated through cryptographic algorithms. This ensures that once a certificate is validated and recorded on the blockchain, it becomes digitally sealed. Any attempt to alter the certificate details would require changing the cryptographic hash, an operation computationally infeasible, thus ensuring the immutability of validated certificates.

Discussions surrounding the results emphasize the potential of blockchain technology to streamline and secure the certificate validation process. The decentralized nature of the blockchain ensures transparency and eliminates the need for a central authority to oversee validation, reducing the risk of fraud and enhancing confidence in the system.

Furthermore, the project's design considerations, including the use of a secure email communication protocol for notifications, contribute to a comprehensive and user-friendly experience. Users receive timely and secure email notifications during the validation process, enhancing communication and keeping them informed about the status of their certificates.

In conclusion, the blockchain-based certificate validation project demonstrates significant advancements in securing and streamlining the validation of educational credentials. The integration of username, password, name, certificate hash, and course name enhances the security, granularity, and reliability of the validation process. The results underscore the transformative potential of blockchain technology in revolutionizing the verification of academic achievements.

Criteria	Blockchain-Based Certificate Validation	Existing Methods
Security	Utilizes decentralization and cryptographic hashing to establish resistance against tampering. Maintains data integrity through immutability.	Conventional methods involve the issuance of physical certificates featuring seals and signatures, while digital approaches rely on secure databases and encryption for certificate storage and verification.
Transparency	Establishing a decentralized ledger enhances transparency, fostering increased trust among stakeholders.	Traditional certificates may lack transparency, which can be addressed through digital methods utilizing centralized databases.

Criteria	Blockchain-Based Certificate Validation	Existing Methods
Efficiency	Reduced reliance on central authorities is achieved through decentralization.	Traditional methods often require manual verification procedures, while online platforms can enhance efficiency through digital validation methods.
Adoption Potential	Presents an innovative approach, especially in industries that prioritize the authentication of credentials and the establishment of trust.	Digital methods are commonly used, while traditional methods are deeply rooted. The acceptance of blockchain technology may depend on the industry's readiness to embrace it.
Consideration and Challenges	The consensus process and the blockchain platform are integral components of security, while scalability may pose challenges.	Traditional paper certificates face challenges such as the risk of loss or damage, while digital methods may encounter problems related to standardization and interoperability.

Table 9.1: Result obtained vs Existing Method

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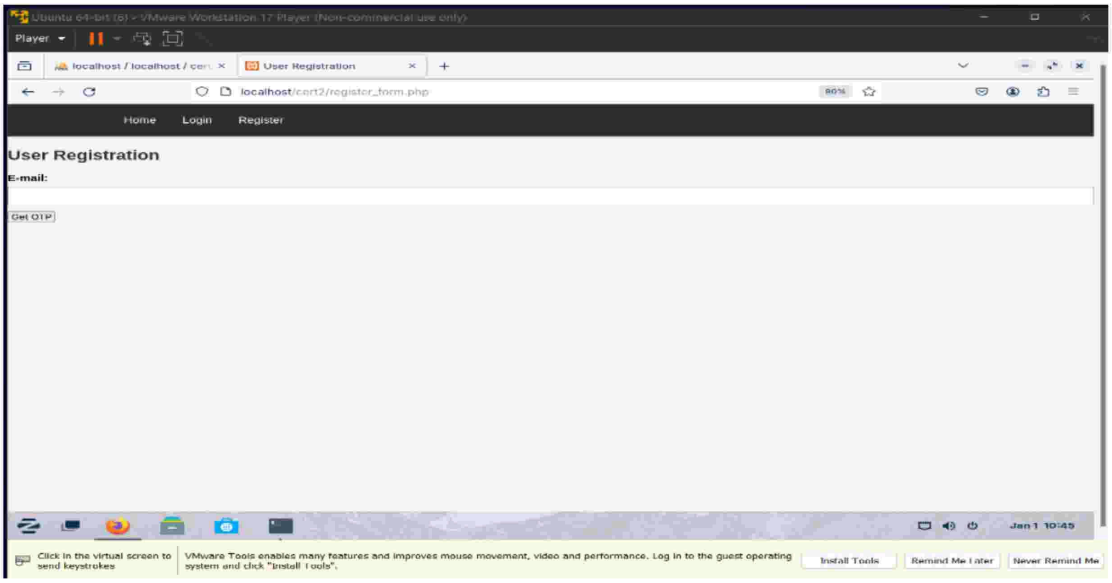
APPENDIX-A

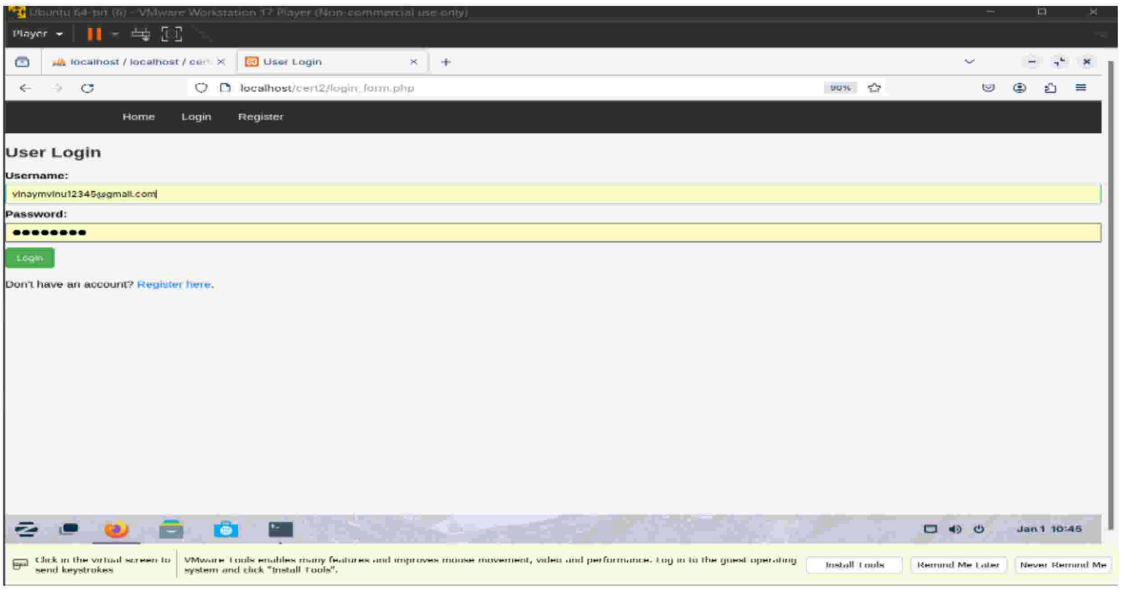
PSEUDOCODE

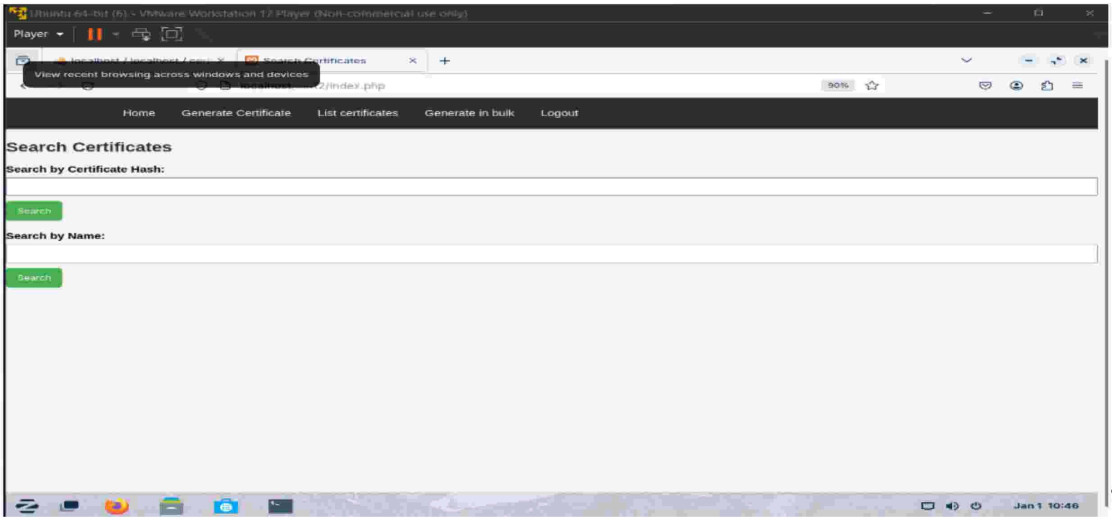
```
Function validateCertificate(certificate):
    // Extract necessary information from the certificate
    certificateHash = certificate.hash
    issuerPublicKey = certificate.issuerPublicKey
    signature = certificate.signature

    // Retrieve the public key of the certificate issuer
    issuerPublicKeyFromBlockchain = blockchain.getPublicKey(certificate.issuerID)

    // Verify the signature using the issuer's public key
    if verifySignature(certificateHash, signature, issuerPublicKeyFromBlockchain):
        // Signature is valid, proceed to further checks

        // Check if the certificate is not expired
        if certificate.expiryDate > getCurrentDate():
            // Additional validation steps can be added here

            // Certificate is valid
            return true
        else:
            // Certificate has expired
            return false
    else:
        // Signature is not valid
        return false
```

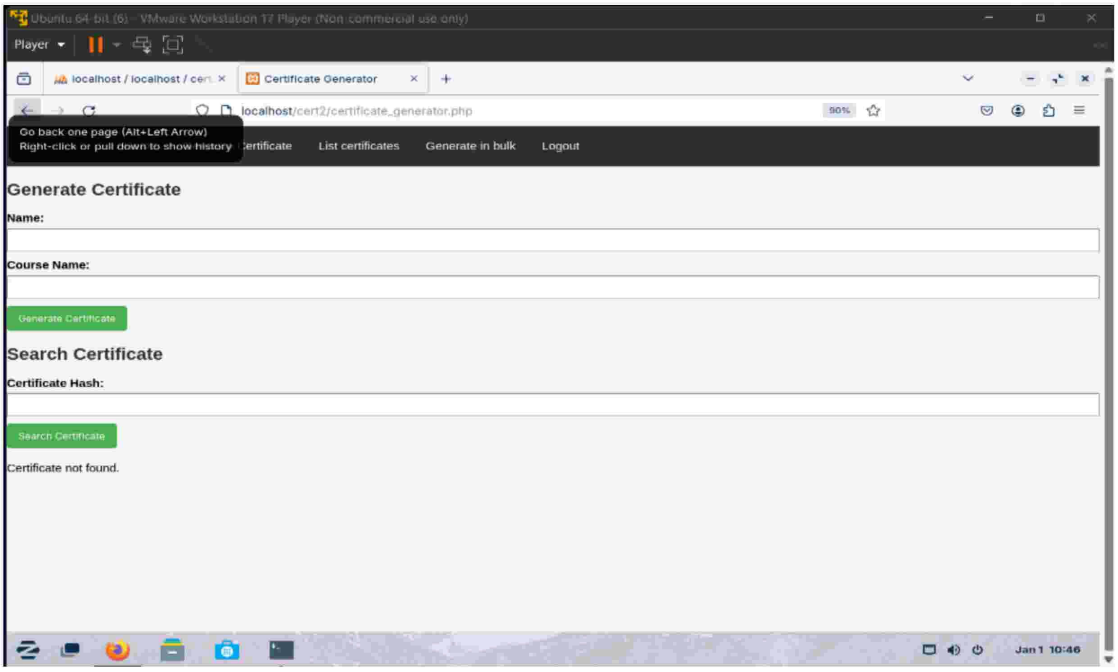
APPENDIX-B

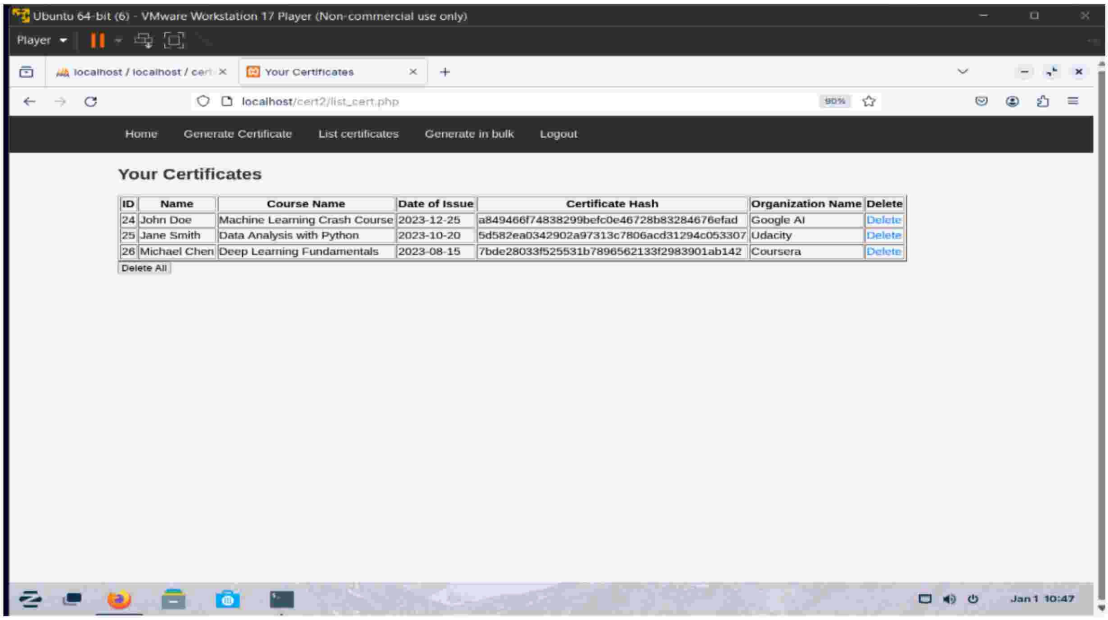
SCREENSHOTS






Player
View recent browsing across windows and devices
Home
Generate Certificate
List certificates
Generate in bulk
Logout
Search Certificates
Search by Certificate Hash:
Search
Search by Name:
Search
Jan 1 10:46


Player
Certificate Generator
localhost/cert2/certificate_generator.php
Go back one page (Alt+Left Arrow)
Right-click or pull down to show history
List certificates
Generate in bulk
Logout
Generate Certificate
Name:
Course Name:
Generate Certificate
Search Certificate
Certificate Hash:
Search Certificate
Certificate not found.
Jan 1 10:46


Ubuntu 64-bit (6) - VMware Workstation 17 Player (Non-commercial use only)
Player
localhost / localhost / cert
Your Certificates
localhost/cert2/list_cert.php
Home
Generate Certificate
List certificates
Generate in bulk
Logout
Your Certificates
ID
Name
Course Name
Date of Issue
Certificate Hash
Organization Name
Delete
24
John Doe
Machine Learning Crash Course
2023-12-25
a849466f74838299befc0e46728b83284676efad
Google AI
Delete
25
Jane Smith
Data Analysis with Python
2023-10-20
5d582ea0342902a97313c7806acd31294c053307
Udacity
Delete
26
Michael Chen
Deep Learning Fundamentals
2023-08-15
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Coursera
Delete
Delete All
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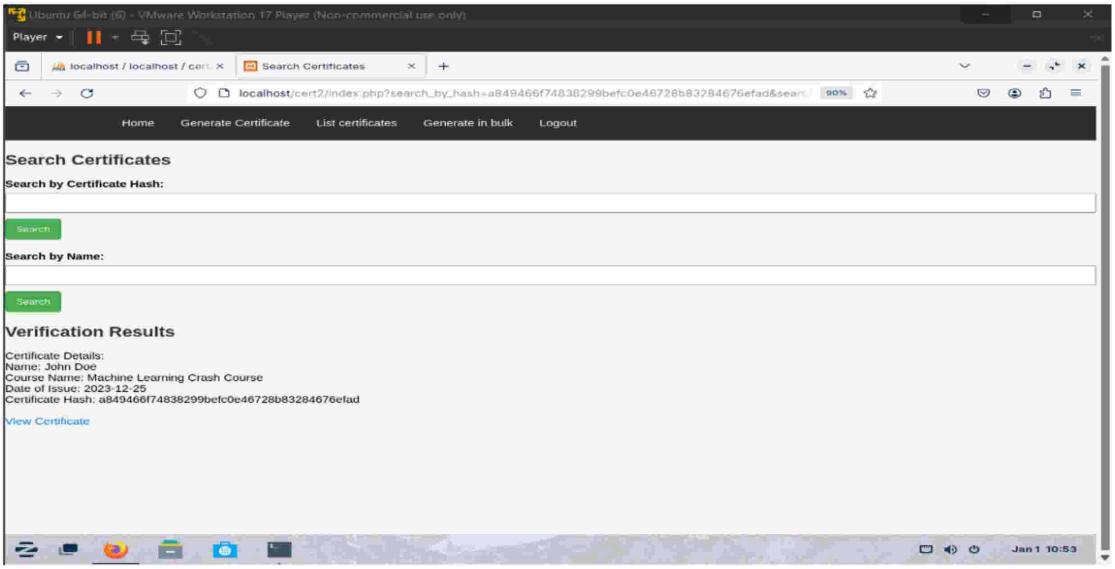
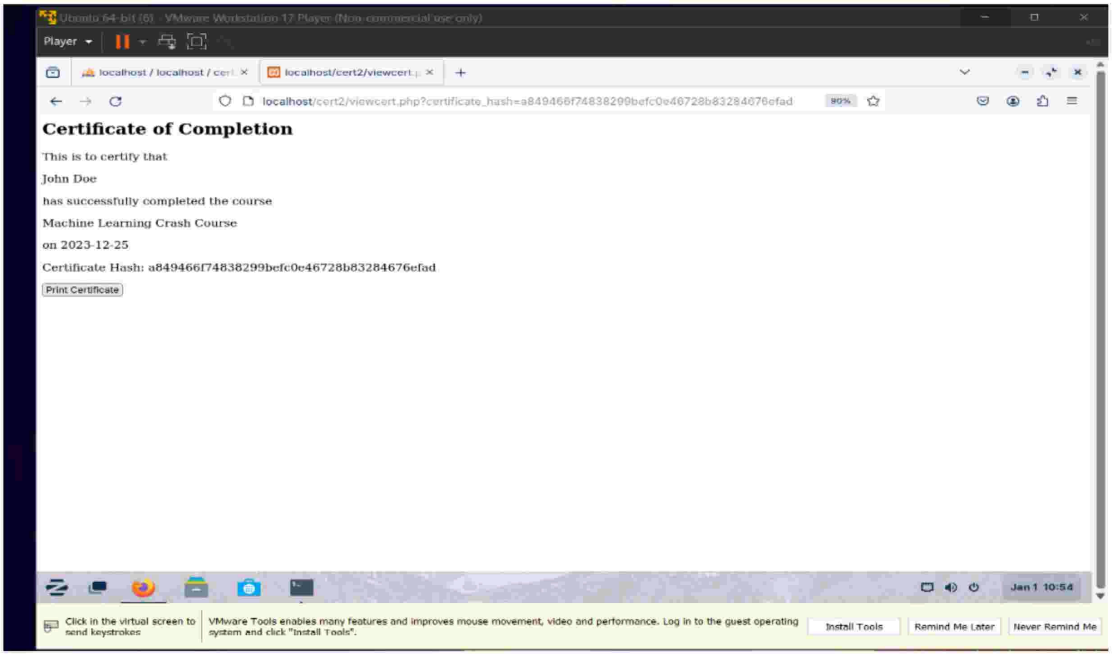
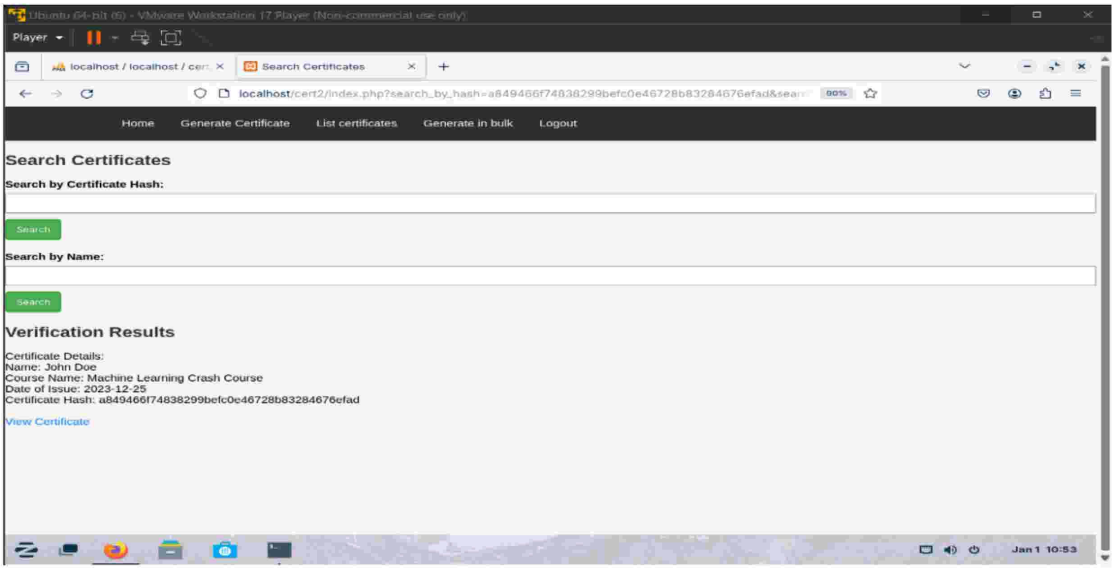
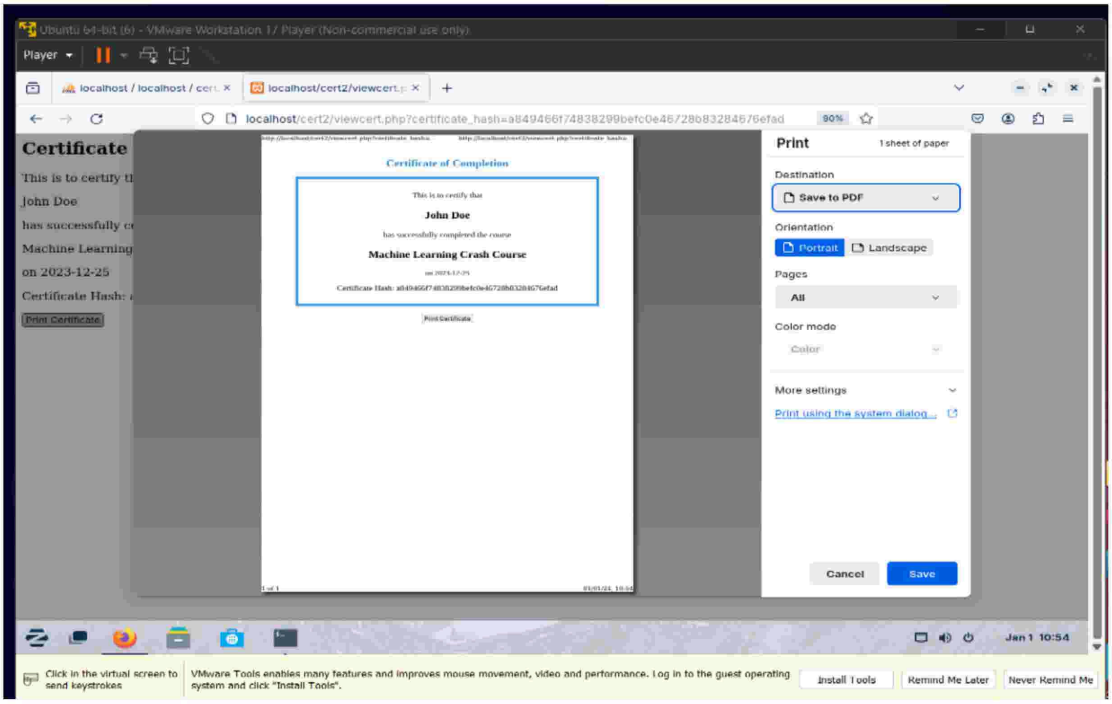

Ubuntu 64-bit (6) - VMware Workstation 17 Player (Non-commercial use only)
Player
localhost / localhost / cert
Search Certificates
localhost/cert2/index.php?search_by_hash=a849466f74838299befc0e46728b83284676efad&sear
Home
Generate Certificate
List certificates
Generate in bulk
Logout
Search Certificates
Search by Certificate Hash:
Search
Search by Name:
Search
Verification Results
Certificate Details:
Name: John Doe
Course Name: Machine Learning Crash Course
Date of Issue: 2023-12-25
Certificate Hash: a849466f74838299befc0e46728b83284676efad
View Certificate
Jan 1 10:53


Certificate of Completion
This is to certify that
John Doe
has successfully completed the course
Machine Learning Crash Course
on 2023-12-25
Certificate Hash: a849466f74838299befc0e46728b83284676efad
Print Certificate


Home
Generate Certificate
List certificates
Generate in bulk
Logout
Search Certificates
Search by Certificate Hash:
Search
Search by Name:
Search
Verification Results
Certificate Details:
Name: John Doe
Course Name: Machine Learning Crash Course
Date of Issue: 2023-12-25
Certificate Hash: a849466f74838299befc0e46728b83284676efad
View Certificate

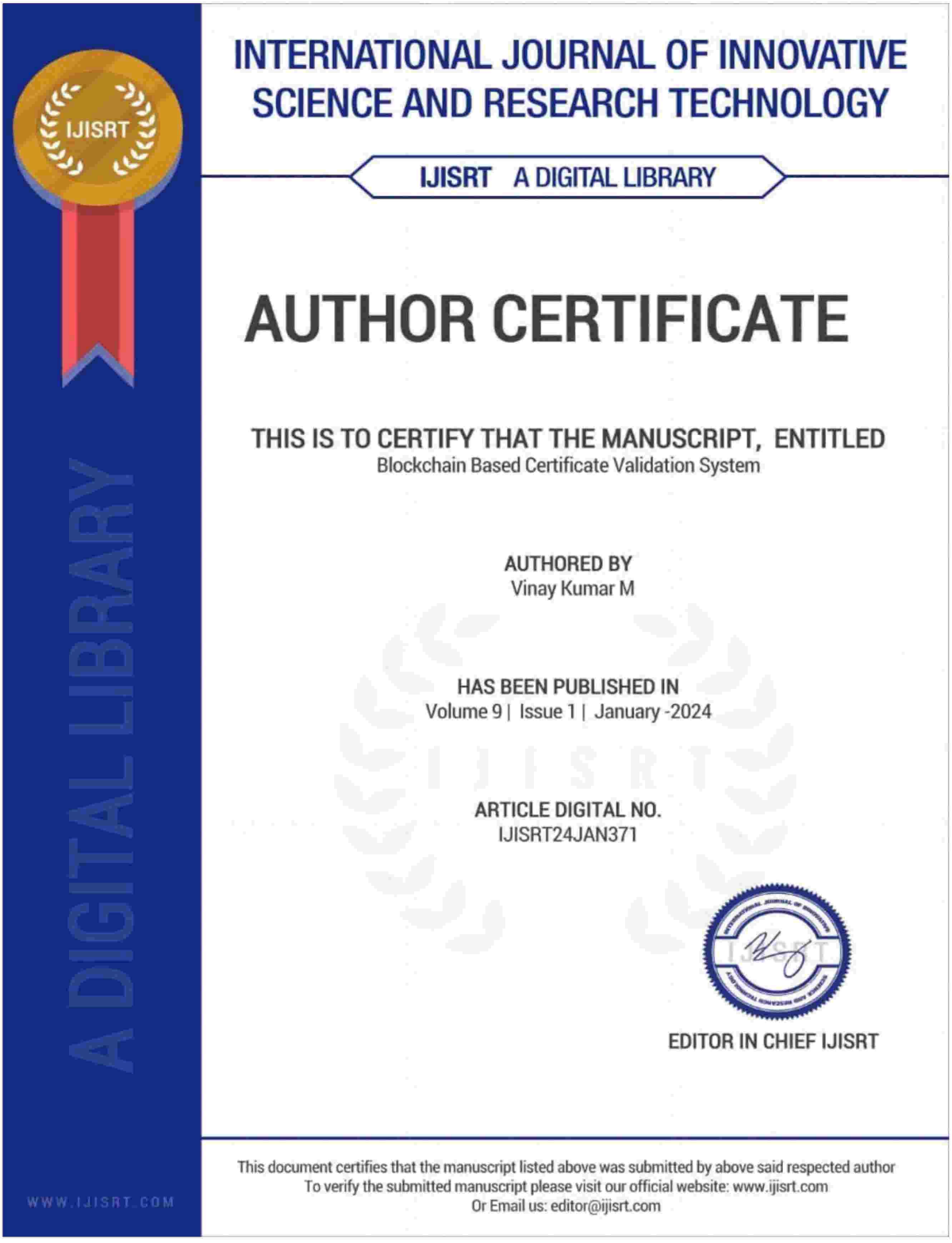

Ubuntu 64-bit (6) - VMware Workstation 17 Player (Non-commercial use only)
Player
localhost / localhost / cert
localhost/cert2/viewcert.p
localhost/cert2/viewcert.php?certificate_hash=a849466f74838299befc0e467280832845 76efad
90%
Certificate
This is to certify th
John Doe
has successfully c
Machine Learning
on 2023-12-25
Certificate Hash:
Print Certificate
Certificate of Completion
This is to certify that
John Doe
has successfully completed the course
Machine Learning Crash Course
Print
1 sheet of paper
Destination
Save to PDF
Orientation
Portrait
Landscape
Pages
All
Color mode
Color
More settings
Print using the system dialog...
Cancel
Save
Jan 1 10:54
Click in the virtual screen to send keystrokes
VMware Tools enables many features and improves mouse movement, video and performance. Log in to the guest operating system and click "Install Tools".
Install Tools
Remind Me Later
Never Remind Me

APPENDIX-C

ENCLOSURES

Certificates of Publication Paper Form

International Journal of Creative Research Thoughts



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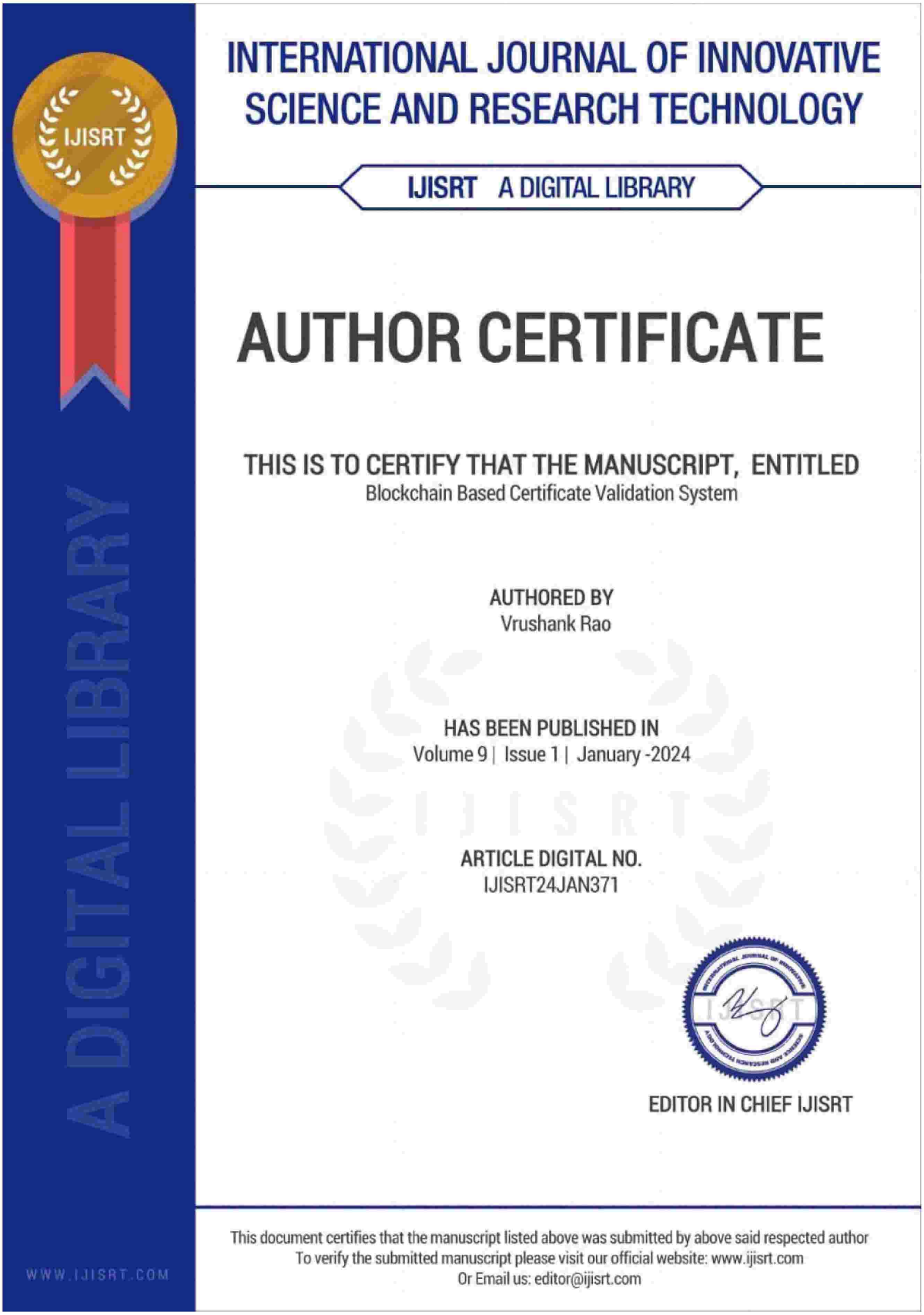

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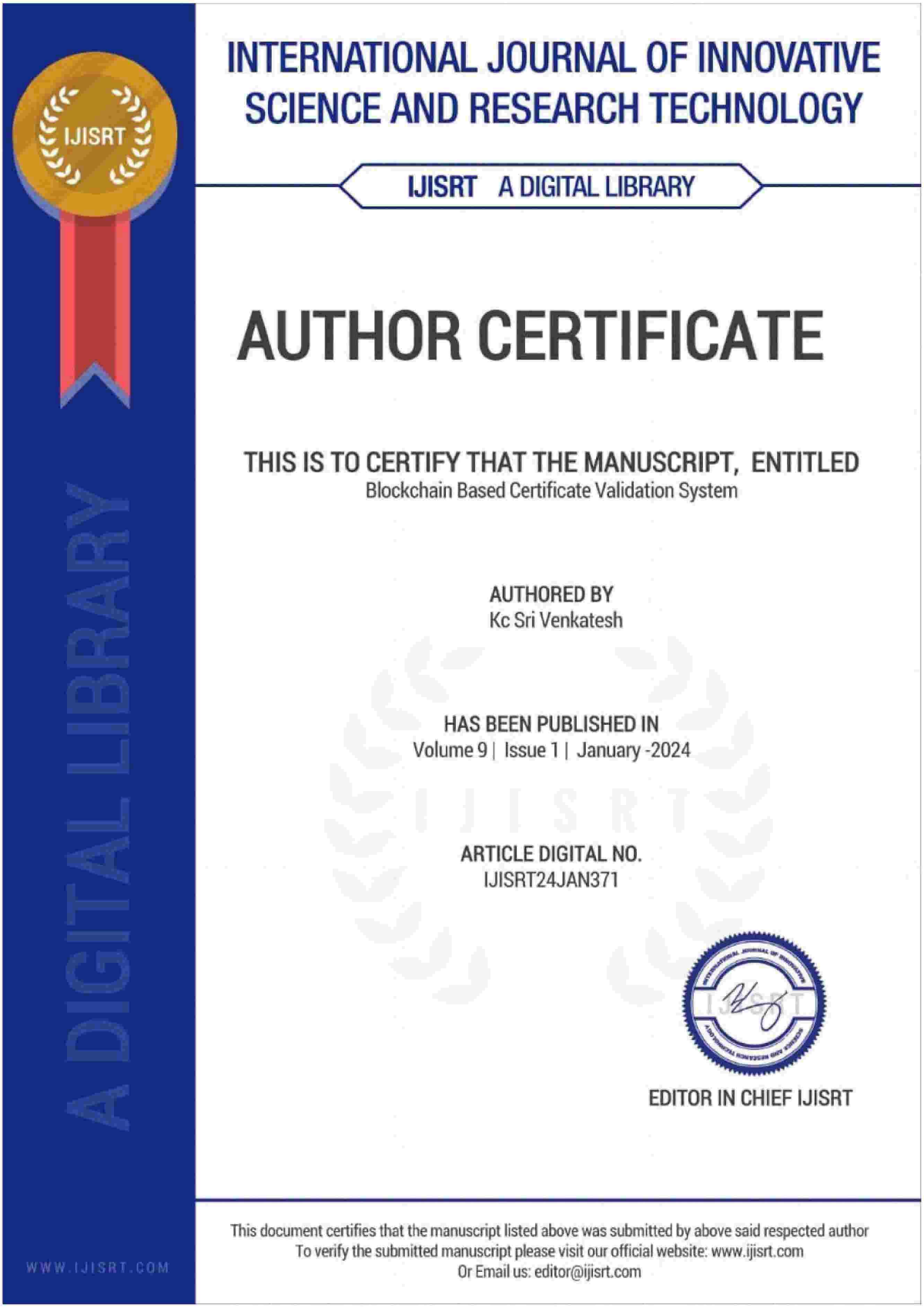

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Sustainable Development Goals

The Project work carried out here is mapped to SDG-4 Quality Education.

The project work carried out here promotes inclusive and equitable quality education by ensuring the authenticity of educational certificates, reducing fraud, and facilitating global recognition of qualifications. This contributes to building a more sustainable and accessible education system worldwide.