ABSTRACT

The Blockchain-Based Certificate Verification System is a secure and easy way to store and check educational and professional credentials. It uses blockchain technology to make sure certificates cannot be changed or faked. Users can save the digital fingerprints (hashes) of their certificates on a blockchain, which keeps a permanent record of issuance and verification. This system allows for quick and reliable checking by comparing the stored hashes with the ones provided. It also offers a public, verifiable record of when certificates were issued and any changes made. By simplifying the verification process, the system reduces fraud, improves efficiency, and builds trust in credential verification. At its core, the system uses cryptographic hashing to generate unique digital fingerprints for each certificate. These hashes are then securely stored on a blockchain, a decentralized and immutable digital ledger. Once recorded, these digital fingerprints cannot be altered or deleted, ensuring the authenticity and integrity of the stored credentials. Whenever a certificate needs verification, the system compares the hash of the presented certificate with the one stored on the blockchain. If they match, the certificate is confirmed as genuine.

CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

In today's digital age managing and verifying educational certificates and professional credentials in traditional systems present several technical and operational challenges. Conventional methods rely heavily on centralized databases, which are vulnerable to unauthorized access, data breaches, and tampering. Additionally, the verification process typically involves manual intervention, which is time-consuming, prone to errors, and lacks transparency. This reliance on centralized intermediaries often creates inefficiencies and raises questions about the trustworthiness of credentials.

To address these issues, blockchain technology offers a robust solution. Blockchain, with its decentralized and distributed ledger, ensures immutability, transparency, and enhanced security of stored data. By using cryptographic algorithms, sensitive information such as certificate details can be securely hashed and stored on the blockchain. This approach eliminates the risk of unauthorized modifications while ensuring that certificates are verifiable by any authorized party. The immutability of blockchain makes it an ideal choice for building a secure and reliable certificate management system, revolutionizing how credentials are stored and authenticated.

1.1 Overview

The primary goal of this project is to design and implement a blockchain-based platform for storing and verifying educational certificates and professional credentials. By leveraging blockchain technology, the system aims to ensure data integrity, security, and transparency, eliminating the risk of tampering or forgery. This solution not only streamlines the verification process for stakeholders such as employers and educational institutions but also empowers certificate holders with secure and easily accessible digital credentials.

The subsequent sections of this report provide a comprehensive overview of the system's architecture, design, and implementation. They highlight the technical decisions, challenges encountered, and solutions adopted during the development process. Through this project, we aim to deliver a robust and scalable solution for certificate management, fostering trust and efficiency in academic and professional ecosystems.

1.2 Literature Review

1. Educational Certificate Verification System Using Blockchain (2020) – Published in the International Journal of Scientific & Technology, this study by Dinesh Kumar K, Senthil P, and Manoj Kumar D.S. **[1]** focuses on using blockchain storage, smart contracts, and decentralization to ensure security in certificate verification. However, the proof-of-work systems used can be costly and energy-intensive.

2. Certificate Validation Using Blockchain (2020) – Published in IEEE, A. Gayathiri, J. Jayachitra, and S. Matilda **[2]** explore converting physical certificates into digital forms, generating hash values, and storing them on a blockchain. Challenges include enhancing user adoption and addressing interoperability issues with existing systems.

3. Blockchain-Based Academic Certificate Verification System (2022) – Published in Springer by Shivani Pathak, Vimal Gupta, Nitima Malsa, Ankush Ghosh, and R.N. Shaw, **[3]** the study highlights blockchain's decentralized and immutable nature for fraud prevention and process streamlining. However, it lacks a detailed discussion on how blockchain will interact with other existing systems.

4. Smart and Secure Certificate Validation System through Blockchain (2020) – In this IEEE publication, Padmavati E. Gundgurti and colleagues **[4]** emphasize the role of smart contracts in automating the verification process. The study identifies challenges in integrating blockchain technology with legacy systems.

5. Blockchain-Based Certificate Verification System Management (2022) – Authored by Qurotul Aini, Eka Purnama Harahap, Nuke Puji Lestari Santoso, Siti Nurindah Sari, and Po Abas Sunarya, **[5]** the paper discusses certificate structure extension, performance evaluation, and comparison with existing methods. Identified gaps include scalability, privacy, data security, network latency, and real-time response issues.

6. Blockchain and Smart Contract for Digital Certificate (2018) – Published in IEEE by Jiin-Chiou Cheng, Narn-Yih Lee, Chien Chi, and Yi-Hua Chen, **[6]** the paper explores generating digital versions of certificates, calculating hash values, and using QR codes for verification. Challenges include user training, ease of use, and long-term maintenance.

7. Academic Certificate Fraud Detection System Framework Using Blockchain Technology (2022) – Published in B-Front by Ninda Lutfiani, Desy Apriani, Efa Ayu Nabila, and Hega Lutfilah Juniar, **[7]** the study emphasizes using digital signatures and timestamps for verification. Gaps include the lack of practical implementation, legal and regulatory hurdles, and low user adoption rates. s

8. Digital Certificate Authority with Cybersecurity in Education (2021) – Published in IJCITSM by Giandari Maulani, Gunawan, Leli Nirmalasari, Efa Ayu Nabila, and Windy Yestina Sari, **[8]** the paper focuses on addressing cybersecurity threats and enhancing trust through blockchain-based databases. However, the study highlights cost implications for implementation as a significant challenge.

9. Implementation of Blockchain for Academic Certificate Authentication (2020) – Published in the Journal of Computer Networks by Charles Kim and Fatima Rahman, **[9]** this study combines QR code-based validation with blockchain to secure academic credentials. Key limitations include slow transaction speeds and insufficient privacy protection in data handling.

10. Blockchain-Powered Verification of Educational Credentials (2021) – Featured in the Computers & Security Journal by Peter Johnson and Wei Zhang, **[10]** the paper introduces a blockchain protocol utilizing smart contracts for automated validation. However, synchronization issues across nodes and high network maintenance costs pose significant challenges.

11. Blockchain in Higher Education: Verification of Certificates (2022) – Published in the Educational Technology Journal by Kevin Roberts and Rina Gupta, **[11]** the study proposes a hybrid approach .

12. Blockchain-Based Certificates in Professional Development and Skill Recognition (2023) – Published in the Journal of Blockchain Research and Development by Michael S. Robinson and Clara Hernandez, **[12]** this study focuses on leveraging smart contracts to automate certificate verification and provide verifiable proof of skills and qualifications. The research highlights the potential of blockchain technology in professional skill recognition systems. However, significant challenges remain, including the lack of infrastructure and universally accepted standards, which hinder widespread adoption and seamless integration across different platforms and industries

Literature Summary

The literature review covers various studies focused on blockchain-based certificate verification systems, highlighting the benefits and challenges of using blockchain for this purpose. Most studies leverage blockchain's decentralized and immutable nature, along with smart contracts, to automate and secure the verification process. Key benefits include improved trust, prevention of fraud, and streamlined verification. However, common challenges persist, such as the integration of blockchain with legacy educational systems, scalability issues, and high energy costs associated with some consensus mechanisms like proof-of-work. Additionally, user adoption, awareness, and interoperability with existing systems are often cited as barriers. Legal and regulatory challenges, slow transaction speeds, and high network maintenance costs further complicate implementation. While newer approaches, like hybrid models using public and private blockchains, aim to balance security and performance, practical implementation and standardization remain significant gaps in the field.

Literature Gaps

• The gaps in blockchain-based certificate verification systems, as observed across various research projects, highlight several critical challenges that need to be addressed for widespread adoption and functionality.

• Key issues include the high cost and energy consumption of proof-of-work systems, as well as the difficulty in achieving interoperability with existing legacy systems.

• Furthermore, scalability remains a persistent concern, particularly in terms of network latency, real-time response, and the ability to handle large volumes of certificates.

• Privacy and data security pose significant risks, as blockchain's transparency can inadvertently expose sensitive information.

• Additionally, user adoption is hindered by a lack of awareness and training, while legal and regulatory frameworks remain underdeveloped, creating uncertainty around long term management and enforcement.

• Finally, the high maintenance costs and synchronization issues across multiple nodes further complicate the practical implementation of these systems.

• Addressing these gaps is essential for making blockchain-based certificate verification systems more efficient, secure, and accessible.

1.3 Problem Statement

The traditional way of verifying educational and professional certificates is slow and easy to tamper with, causing fraud and delays. This creates extra work for schools, employers, and individuals. We need a digital solution for secure, transparent, and efficient verification. Blockchain can provide unchangeable records, reducing fraud and improving efficiency.

1.4 Objectives

- To design and develop user interface for certificate holders, issuers, and verifiers .Enable easy input of certificate details during issuance.
- To develop and handle certificate data and verifications on the blockchain using the smart contract.
- To test and deploy the certificate verification system on the virtual blockchain platform.

1.5 Scope of the Project

1. For Certificate Holders:
   a. Convenient access to securely stored certificates at any time.
   b. Easy sharing of certificate details with employers or educational institutions for verification.
2. For Verifiers (Employers/Educational Institutions):
   a. Real-time verification of certificate authenticity.
   b. Reduced risk of fraudulent certificates through blockchain's immutable nature.
3. For Issuers (Educational Institutions/Certification Bodies):
   a. Streamlined certificate issuance process with secure record-keeping.
   b. Reduced administrative burden by eliminating manual verification requests.
4. Technology Integration:
   a. Use of blockchain for immutable and secure data storage.
   b. Scalability to accommodate future enhancements, such as integration with external systems.
5. Community Impact:
   a. Increased trust and transparency in certificate verification processes.
   b. Support for combating certificate fraud, fostering integrity in academic and professional sectors.

CHAPTER 2

METHODOLOGY

2.1 Methods and Techniques

The development of the **Blockchain-Based Certificate Verification System** will follow a structured and systematic approach to ensure efficient progress and the achievement of project goals. The project will be divided into several phases: **Planning and Requirement Gathering**, **Design**, **Development**, **Testing**, **Deployment**, and **Maintenance**. Below is a detailed outline of each phase:

1. Planning and Requirement Gathering

- **Stakeholder Meetings**: Conducted discussions with key stakeholders such as educational institutions, certification bodies, and employers to gather requirements and understand their needs for certificate verification.
- **Requirement Documentation**: Documented functional and non-functional requirements, outlining the essential features such as certificate upload, verification, and storage on the blockchain.
- **Project Planning**: Developed a detailed project plan, including timelines, milestones, and resource allocation to ensure smooth execution of the project.

2. Design

- **System Architecture**:

  - A simple system architecture will be defined, consisting of users (issuers, holders, verifiers), a backend API, blockchain for storing certificate hashes, and the front-end interface for interacting with the system.

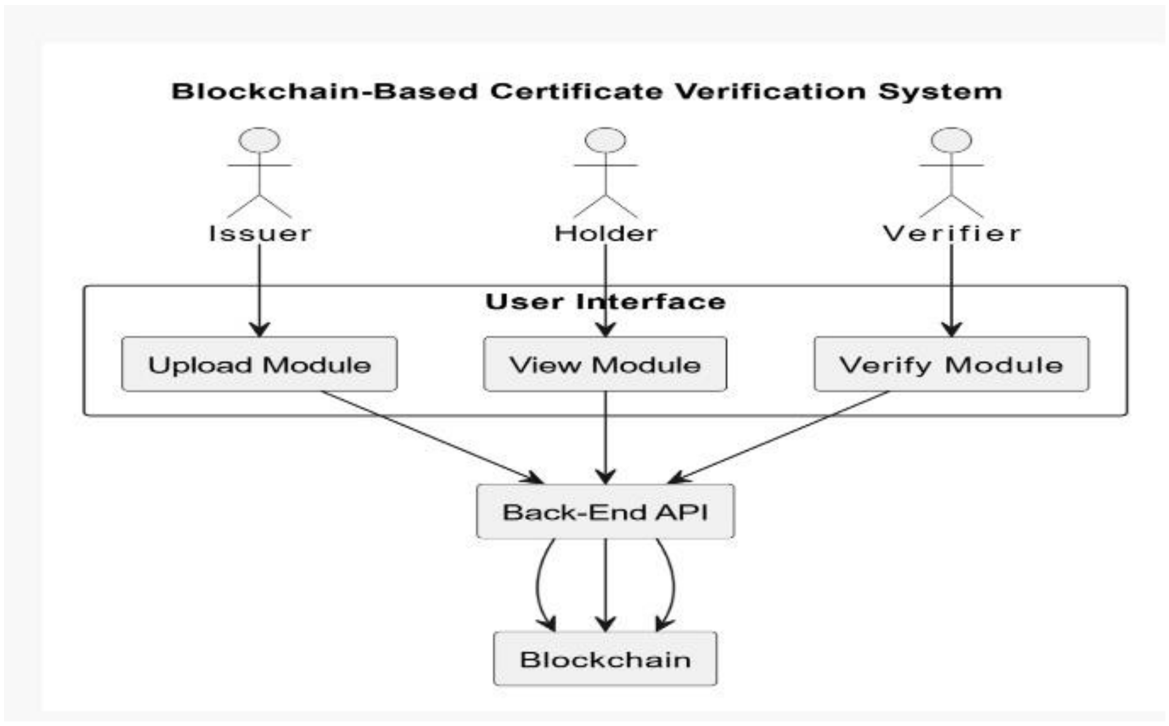


Fig.2.1.1 Methodology Design

Use Case Diagram: A use case diagram will outline the interactions between different system components such as users, certificates, blockchain.

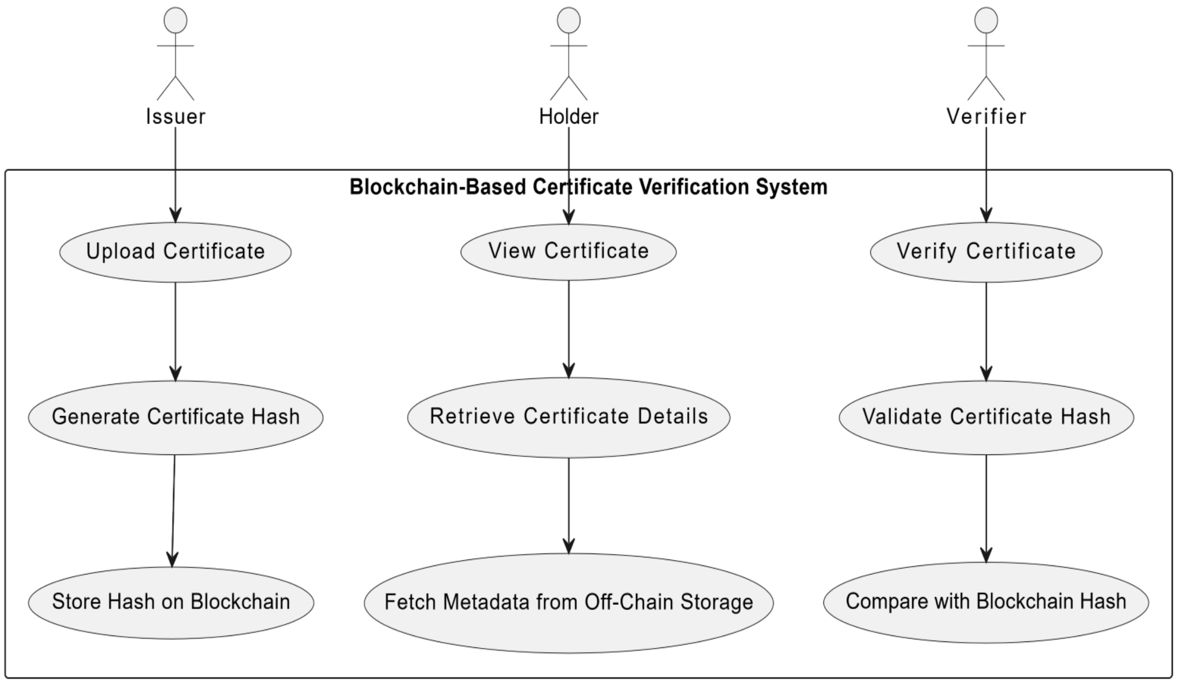

Issuer
Holder
Verifier
Blockchain-Based Certificate Verification System
Upload Certificate
View Certificate
Verify Certificate
Generate Certificate Hash
Retrieve Certificate Details
Validate Certificate Hash
Store Hash on Blockchain
Fetch Metadata from Off-Chain Storage
Compare with Blockchain Hash

Fig.2.1.2 Use case diagram

- **Technical Specifications**:

Documenting the technologies, frameworks, and tools to be used, such as Solidity for smart contracts and Ethereum for blockchain.

- **Database Design**:

The system does not require a traditional relational database but will focus on storing metadata off-chain using appropriate storage solutions like cloud storage for certificates, linked with blockchain hashes.

3. Development

- **Set Up Development Environment**:
    - Install and configure tools such as **Ganache** (for local blockchain development), **Truffle Suite** (for smart contract deployment), **Metamask** (for user interaction with blockchain), and **VS Code** as the code editor.
    - Set up version control using **Git** and host the project on **GitHub** for collaboration and version tracking.
- **Frontend Development**:
    - **HTML/CSS/JavaScript**: Create an intuitive user interface that allows certificate upload, viewing, and verification.
    - **React**: Implement the dynamic frontend using **React.js** for a responsive user experience.
- **Backend Development**:
    - **Smart Contract Setup**: Develop and deploy smart contracts using **Solidity** on the Ethereum blockchain to store the cryptographic hash of certificates.
    - **Blockchain Integration**: Integrate the blockchain network with the system to securely store certificate data.
    - **User Authentication**: Implement secure authentication for users (issuers, holders, verifiers) using **Metamask** for blockchain interaction.
    - **Certificate Upload and Verification**: Implement APIs to allow issuers to upload certificates and verifiers to validate them against the blockchain.

4. Testing

- **Unit Testing**:
  - Write unit tests for individual components, including smart contracts, APIs, and UI elements to ensure they work as expected.
- **Integration Testing**:
  - Perform tests to ensure that the interaction between the blockchain, backend, and frontend is seamless and secure.
- **System Testing**:
  - Conduct end-to-end testing to validate the entire certificate verification process, from uploading to verification.
- **User Acceptance Testing**:
  - Have real users (issuers, holders, verifiers) test the system to ensure it meets their requirements and functions as expected.

5. Deployment

- **Deploy Blockchain Network**:
  - Deploy the smart contracts and the blockchain network on the **Ethereum testnet** (using **Ganache**) for initial testing and then on the **Ethereum mainnet** for production.
- **Deploy Frontend and Backend**:
  - Deploy the frontend on a cloud platform like **Netlify** and backend APIs on **Heroku** or another suitable server.
- **Production Configuration**:
  - Configure production settings for environment variables, database connections, and blockchain interaction.

6. Maintenance

- **Bug Fixes**:
  - Continuously address any issues or bugs reported by users, especially regarding certificate upload, verification, or blockchain interactions.

- **Feature Enhancements**:
  - Implement new features based on user feedback, such as adding support for new certificate types or enhancing the verification process.
- **Performance Optimization**:
  - Optimize the system for better performance, ensuring it can handle large numbers of certificates and verifications efficiently.

2.2 Tools and Technologies

Blockchain Platform:

- Ethereum: A decentralized platform used for deploying smart contracts to ensure immutable and tamper-proof storage of certificate hashes.

Smart Contract Development:

- Solidity: A programming language used to write and deploy smart contracts on the Ethereum blockchain.

Front-End Development:

- HTML/CSS: For creating the structure and styling of the user interface.
- JavaScript: For building dynamic functionalities in the user interface.
- React.js: A JavaScript library for creating interactive and reusable UI components.

Back-End Development:

- Node.js: A JavaScript runtime for building scalable server-side applications.

Blockchain Interaction:

- Web3.js: A JavaScript library used to interact with the Ethereum blockchain and smart contracts.

Development and Testing Tools:

- Ganache: A personal Ethereum blockchain used for deploying and testing smart contracts in a local environment.
- MetaMask: A browser extension for interacting with the Ethereum blockchain, enabling transactions and contract interactions.

2.3 Project Timeline

Week 1: Planning and Initial Setup

Project Planning

- Define project scope and requirements.
- Collaborate with stakeholders to gather requirements.
- Document user stories and acceptance criteria.

Environment Setup

- Set up the development environment (e.g., install necessary tools and frameworks).
- Initialize the blockchain project and app.
- Configure settings and create initial database migrations.

Basic Models and Admin Interface

- Define models for certificates, users, and verification logs.
- Register models with the admin interface.
- Create initial admin user and test the admin interface.

Week 2: Certificate Storage and Verification

Decentralized Storage

- Implement functionality to store cryptographic hashes of certificates on the blockchain.
- Ensure data is securely stored across multiple nodes.

Immutable Record Keeping

- Develop logic to record certificate issuance and verification on the blockchain.
- Ensure the record is tamper-proof and transparent.

Frontend Development

- Design basic HTML/CSS templates for certificate storage and verification pages.
- Ensure responsiveness and user-friendly design.

Week 3: Verification Mechanisms

Efficient Verification

- Create views and templates for verifying certificates.

- Implement forms for certificate verification.
- Validate and compare submitted hashes with those stored on the blockchain.

Frontend Development

- Add JavaScript for form validation and dynamic content updates.
- Enhance user experience on verification pages.

Week 4: Testing and Documentation

Testing

- Conduct unit and integration testing to ensure all components work together.
- Perform user acceptance testing to get feedback from potential users.

Documentation and Final Review

- Write documentation for installation, usage, and maintenance.
- Prepare a final project report and presentation.
- Conduct a final review and address any remaining issues.

CHAPTER 3

SYSTEM DESIGN AND IMPLEMENTATION

3.1 System Architecture

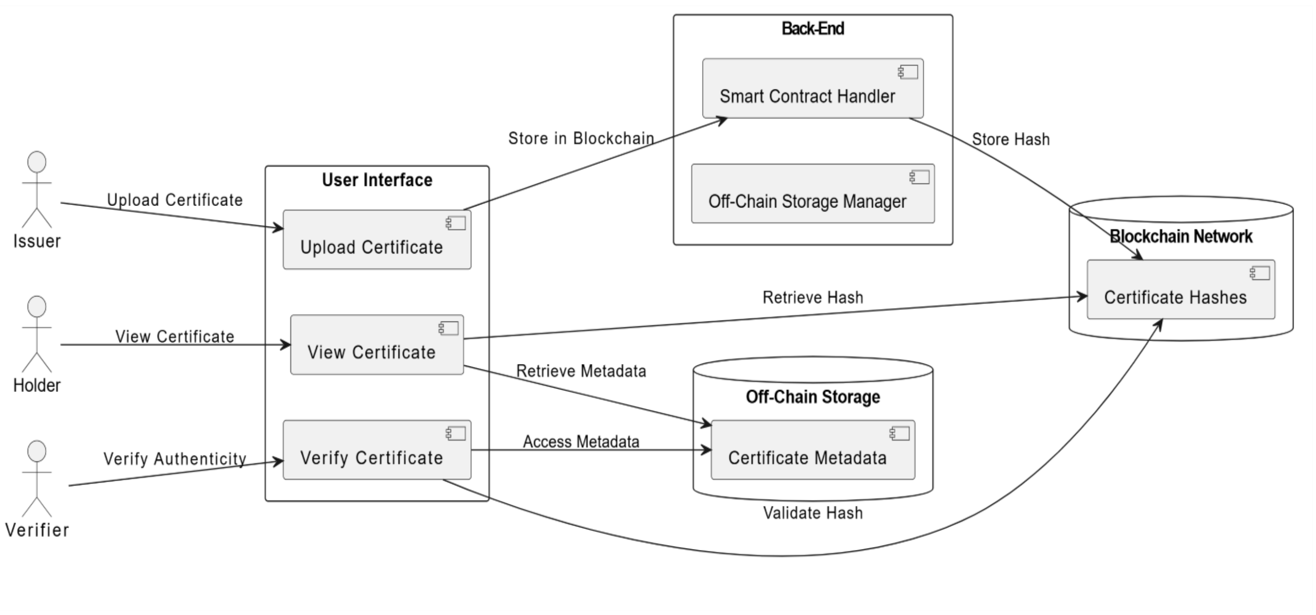


Fig.3.1.1 Architecture

1. User Interface (UI)

The User Interface is the front-end part of the system, providing users with easy-to-use modules for interacting with the platform. It is composed of three main modules:

- Upload Certificate: This module allows the issuer (e.g., educational institution or certification body) to upload certificates. The data provided by the issuer, including the certificate details, is processed and stored.
- View Certificate: This module is used by certificate holders to access and view their uploaded certificates. The holder can retrieve both the certificate hash (from the blockchain) and metadata (from off-chain storage).
- Verify Certificate: This module is used by verifiers (e.g., employers or educational bodies) to verify the authenticity of a certificate. The verifier can check the certificate's hash against the blockchain and access the metadata for verification.

2. Back-End API

- Smart Contract Handler: This component manages interactions with the blockchain. It stores the hash of the uploaded certificate on the blockchain and provides an interface to verify the integrity of the certificate by validating the hash.

3. Blockchain Network

- Certificate Hashes: The hash of each uploaded certificate is stored on the blockchain. This guarantees the certificate's authenticity and ensures that it cannot be tampered with once stored.

System Flow

1. **Certificate Issuance:**

a. The Issuer uploads a certificate using the Upload Certificate module.

b. The Smart Contract Handler processes the uploaded certificate data and generates a hash, which is stored on the Blockchain Network.

c. Simultaneously, the Off-Chain Storage Manager saves the metadata and certificate files in off-chain storage.

2. **Certificate Viewing:**

a. The Holder accesses the View Certificate module and retrieves their certificate details. The system fetches the certificate hash from the blockchain and the metadata from off-chain storage.

3. **Certificate Verification:**

a. The Verifier accesses the Verify Certificate module and checks the certificate's authenticity by validating the hash against the blockchain. The verifier can also retrieve the certificate metadata from off-chain storage for additional details.

Key Features and Benefits

- Security and Immutability: By storing certificate hashes on the blockchain, the system ensures that certificates are tamper-proof and cannot be altered without detection.
- Transparency: The blockchain allows anyone to independently verify the authenticity of a certificate, providing transparency in the verification process.

- Efficiency: The off-chain storage allows for storing large certificate files and metadata while keeping the blockchain lean and efficient.
- Decentralization: The blockchain system eliminates the need for a central authority, enabling a decentralized verification system that is both secure and accessible.

3.2 Component Design

1. User Interface (UI)

- Upload Certificate Module:
  - Allows Issuers to upload certificates.
  - Input fields for certificate details, upload button, feedback on success or failure.
  - Sends certificate details to the Back-End API for processing.
- View Certificate Module:
  - Enables Holders to view their uploaded certificates.
  - Search functionality, displays metadata and certificate hash, download option for certificate files.
  - Fetches certificate details from the Blockchain Network and Off-Chain Storage.
- Verify Certificate Module:
  - Allows Verifiers to check certificate authenticity.
  - Input field for certificate ID or hash, validate certificate hash, display metadata.
  - Validates certificate hash against the Blockchain Network and retrieves metadata from Off-Chain Storage.

2. Back-End API

- Smart Contract Handler:
  - Manages blockchain interactions and stores certificate hashes.
  - Generates certificate hash, stores on blockchain, validates certificate integrity.
  - Stores hashes on the Blockchain Network and validates them.
- Off-Chain Storage Manager:

- Manages metadata and files for certificates stored off the blockchain.
- Stores metadata and certificate files securely.
- Stores and retrieves metadata and files for certificate verification.

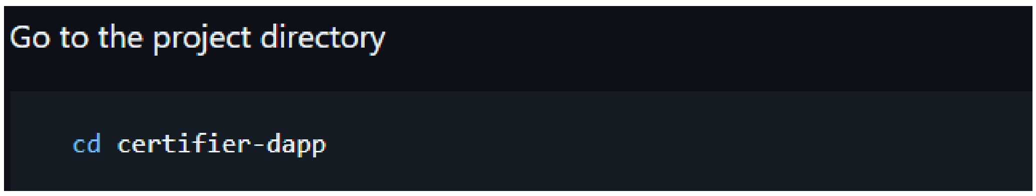
3. Blockchain Network

- Certificate Hashes:
  - Stores cryptographic hashes of certificates.
  - Immutable, secure storage of hashes, enables certificate verification.
  - Receives and stores hashes from the Smart Contract Handler.

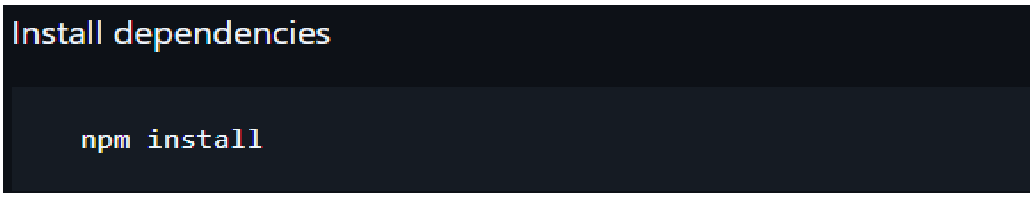
Component Interactions and Workflow

- Issuance:
  - Issuer uploads a certificate, generating a hash stored on the Blockchain Network. Metadata and files are saved in Off-Chain Storage.
- Viewing:
  - Holder views certificates by providing an identifier. The system retrieves the certificate hash from the blockchain and metadata from off-chain storage.
- Verification:
  - Verifier checks the certificate's hash against the blockchain and retrieves metadata from off-chain storage for validation.

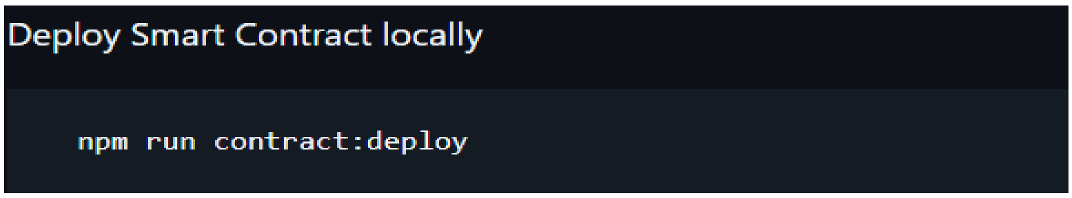
3.3 Implementation Details


Go to the project directory

```
cd certifier-dapp
```

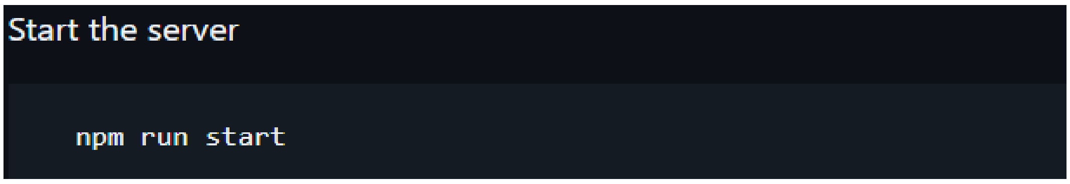

Install dependencies

```
npm install
```



Deploy Smart Contract locally

```
npm run contract:deploy
```



Start the server

```
npm run start
```

Pseudo Code

Smart Contract

```
contract CertificateContract {
    // Event declaration to log certificate creation
    event CertificateWrite(
        address indexed issuedBy,
        address indexed issuedTo,
        string indexed id,
        Certificate certificate;
    );
// Define a structure for storing certificate details
    struct Certificate {
        string id;
        string createdAt;
        string expireAt;
        address issuedBy;
        address issuedTo;
            string data;                              }
// Mapping to store certificates by their unique IDs
    mapping(string => Certificate) public certificates;
// Function to create a new certificate
    function create(
        string memory id,
        string memory data,
        address issuedTo,
        string memory expireAt,
        string memory createdAt
    ) public {
        Certificate memory c;
        c.createdAt = createdAt;
        c.expireAt = expireAt;
        c.issuedTo = issuedTo;
        c.issuedBy = msg.sender;
        c.data = data;
        c.id = id;
        certificates[id] = c; //Store the certificate in the mapping
        emit CertificateWrite(msg.sender, issuedTo, id, c);
          // Emit an event to log the certificate creation
    }       }
```

Issue Certificate

```
import './styles.scss';
import { SideNav } from '../../component/SideNav';
import {ReactComponent as VerifiedIcon} from '../../assets/verified.svg'
import { useEffect, useRef, useState } from 'react';
import web3 from '../../web3/proxy';
// State variables
export function CreatePage() {
    const [certificates, setCertificates] = useState([])
    const [id, setId] = useState(null)
// References to form elements
    const title = useRef(null)
    const name = useRef(null)
    const issuedTo = useRef(null)
    const expireAt = useRef(null)
    const createdAt = useRef(null)
    const description = useRef(null)
// Function to connect to web3 and retrieve issued certificates
    const onConnect = async () => {
        const account = await web3.getAccount()
        const certificates = await web3.getCertificateByIssuer(account.address)
        setCertificates(certificates)                              }
// Function to handle certificate creation or update
    const handleCreate = async () => {
        try {
            const certificate = await web3.createCertificate({
                issuedTo: issuedTo.current.value,
                expireAt: expireAt.current.value,
                createdAt: createdAt.current.value,
                title: title.current.value,
                name: name.current.value,
                description: description.current.innerText
            }, id)
            setCertificates([certificate, ...certificates])
        } catch (error) {
            alert(error)
        }     }
// Update certificate editor based on selected certificate
    useEffect(() => {
        if(!id) return
        const certificate = certificates.filter(c => c.id === id)[0]
        title.current.value = certificate?.data.title || ''
        name.current.value = certificate?.data.name || ''
        issuedTo.current.value = certificate?.issuedTo || ''
        description.current.innerText = certificate?.data.description || ''
        createdAt.current.value = certificate?.createdAt ?
certificate.createdAt.toISOString().split('T')[0] : ''
```

```
        expireAt.current.value = certificate?.expireAt ?
certificate.expireAt.toISOString().split('T')[0] : ''
    }, [id])
```

Verify Certificate

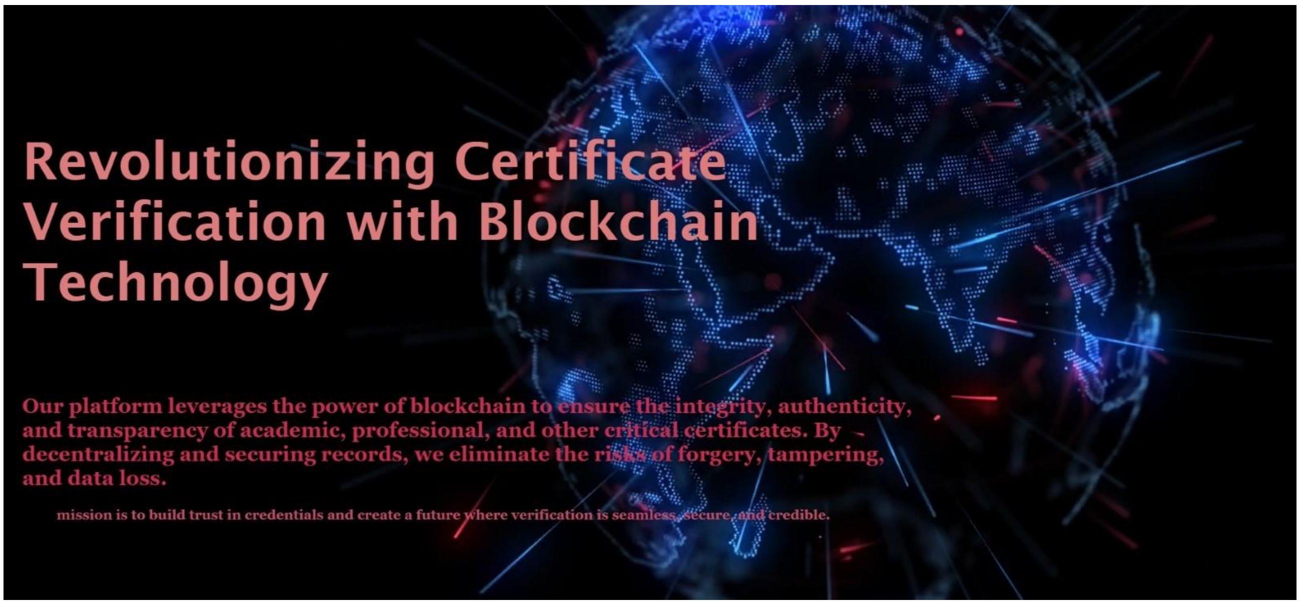
```
import styles.scss
import SideNav component
import VerifiedIcon component
import useRef, useState hooks
import web3 from web3/proxy
function VerifyPage:
    // Declare a ref to hold the ID
    id = useRef(null)
    // Initialize state for certificates with placeholder data
    certificates, setCertificates = useState([                    {
            id: '######',
            expireAt: '######',
            createdAt: '######',
            issuedTo: '######',
            issuedBy: '######',
            data: {
                title: '######',
                name: '######',
                description: '######'
            }         }     ])
    // Initialize state for message and index
    message, setMessage = useState(null)
    index, setIndex = useState(0)
    // Retrieve the current certificate based on the index
    certificate = certificates[index]
    // Function to handle finding a certificate by ID
    function handleFindById:
        if id.current is null:
```

```
    return
// Set certificates state to loading placeholders
setCertificates([                    {
        id: 'Loading...',
        expireAt: 'Loading...',
        createdAt: 'Loading...',
        issuedTo: 'Loading...',
        issuedBy: 'Loading...',
        data: {
            title: 'Loading...',
            name: 'Loading...',
            description: 'Loading...'
        }          }        ])
try:
    // Attempt to retrieve certificates by ID using web3
    certificates = await web3.getCertificateById(id.current.value)
    if certificates is not empty:
        print(certificates)
        setCertificates(certificates in reverse order)
        setMessage(false)
    else:
        setMessage("Certificate Not Found!")
        setCertificates([])
catch error:
    setMessage(error)
    setCertificates([])
```

CHAPTER 4

RESULTS AND DISCUSSION

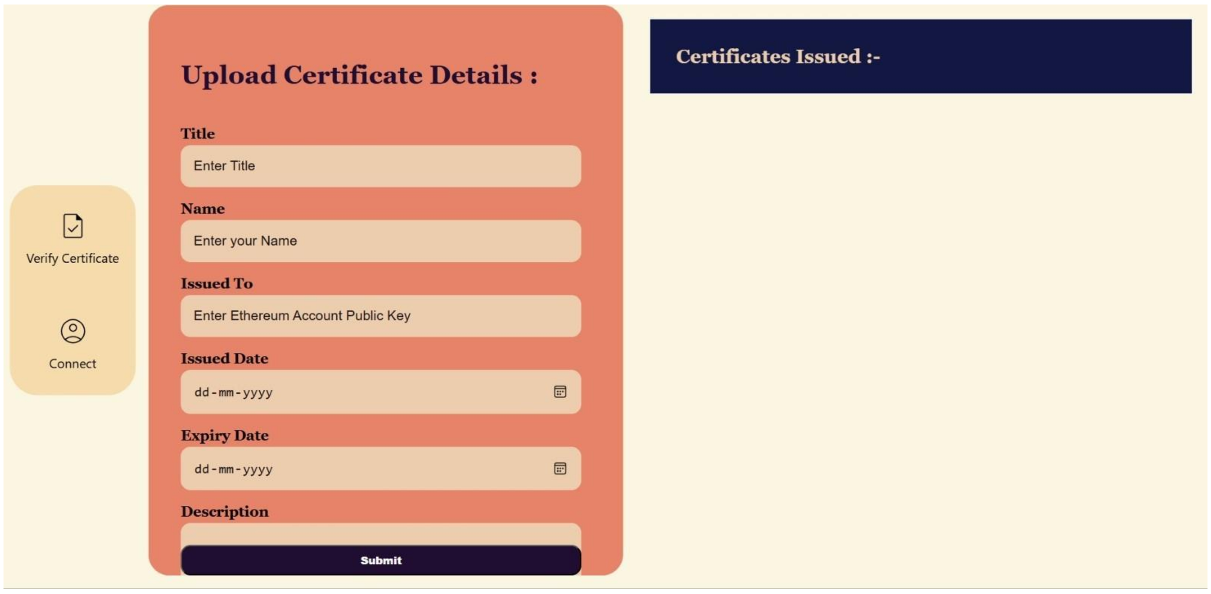
4.1 Presentation of Results


Revolutionizing Certificate Verification with Blockchain Technology

Our platform leverages the power of blockchain to ensure the integrity, authenticity, and transparency of academic, professional, and other critical certificates. By decentralizing and securing records, we eliminate the risks of forgery, tampering, and data loss.

mission is to build trust in credentials and create a future where verification is seamless, secure, and credible.

Fig.4.1.1 Dashboard



Upload Certificate Details :

Title

Enter Title

Name

Enter your Name

Issued To

Enter Ethereum Account Public Key

Issued Date

dd-mm-yyyy

Expiry Date

dd-mm-yyyy

Description

Certificates Issued :-

Fig.4.1.2 Upload Certificate

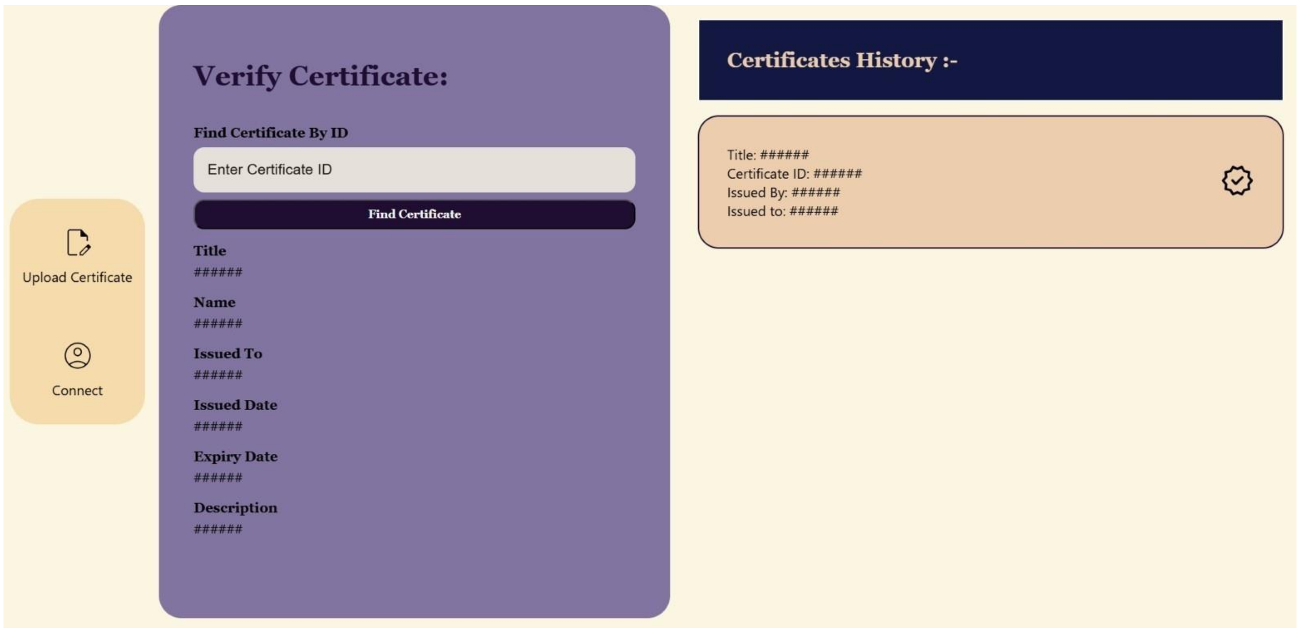


Fig.4.1.3 Verify Certificate

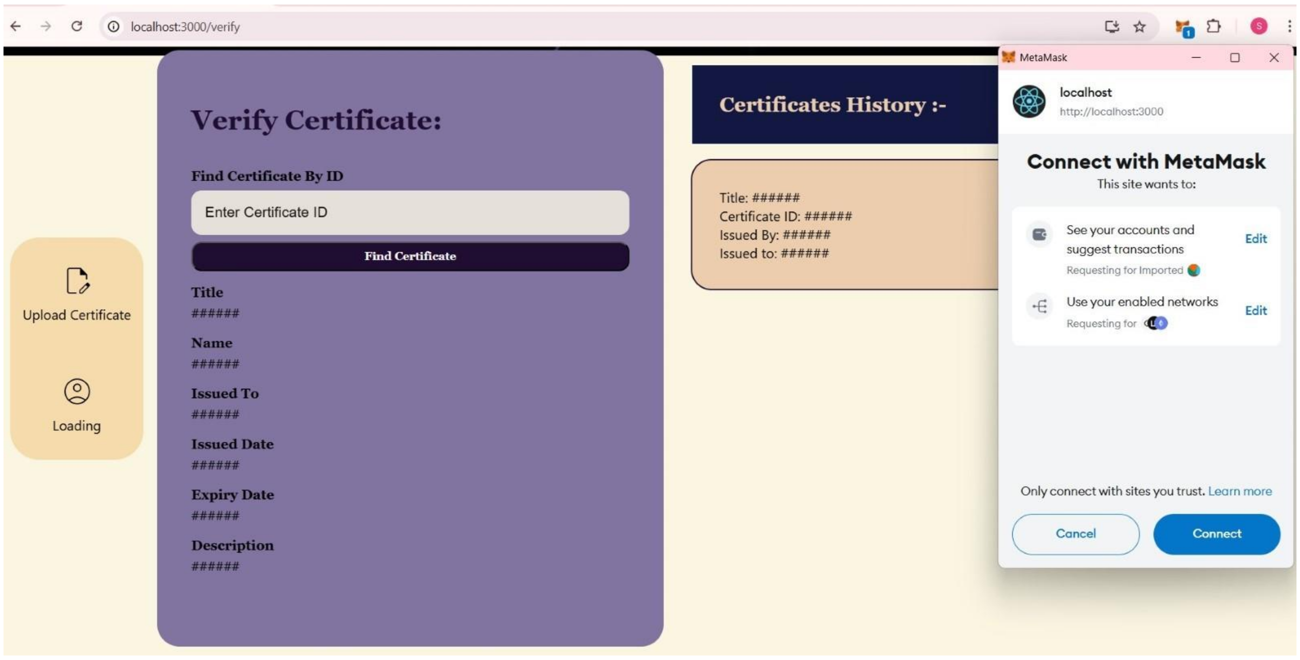
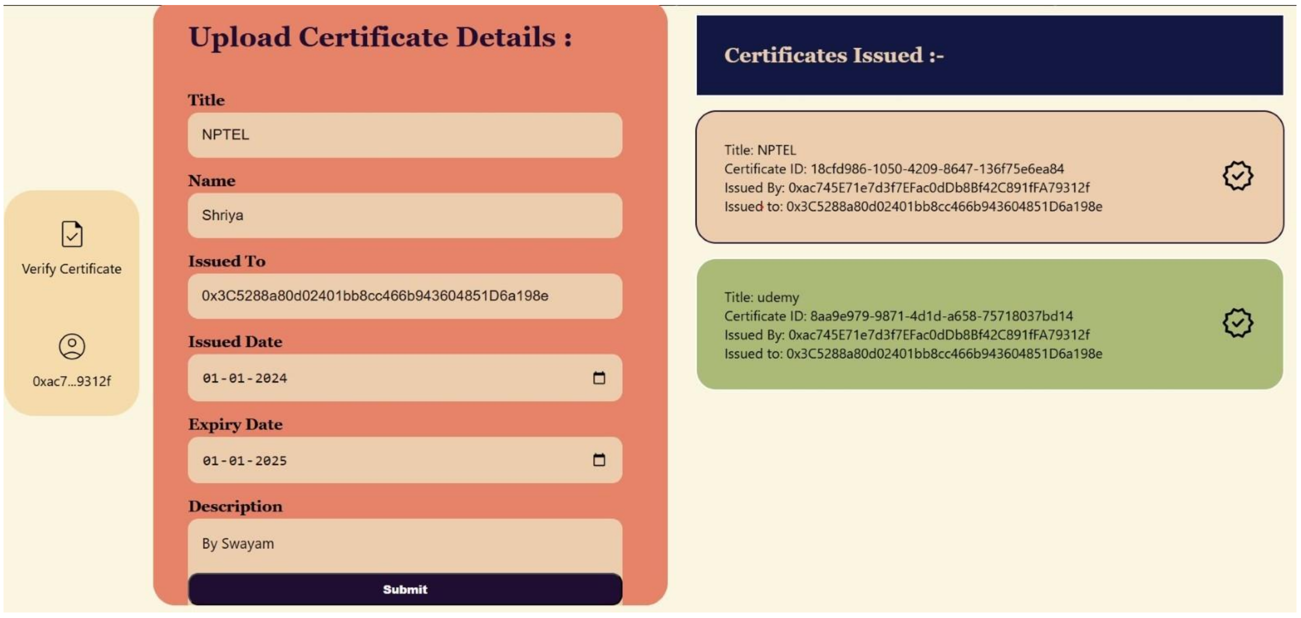


Fig.4.1.4 MetaMask Connect



Verify Certificate

0xac7...9312f

Upload Certificate Details :

Title: NPTEL

Name: Shriya

Issued To: 0x3C5288a80d02401bb8cc466b943604851D6a198e

Issued Date: 01-01-2024

Expiry Date: 01-01-2025

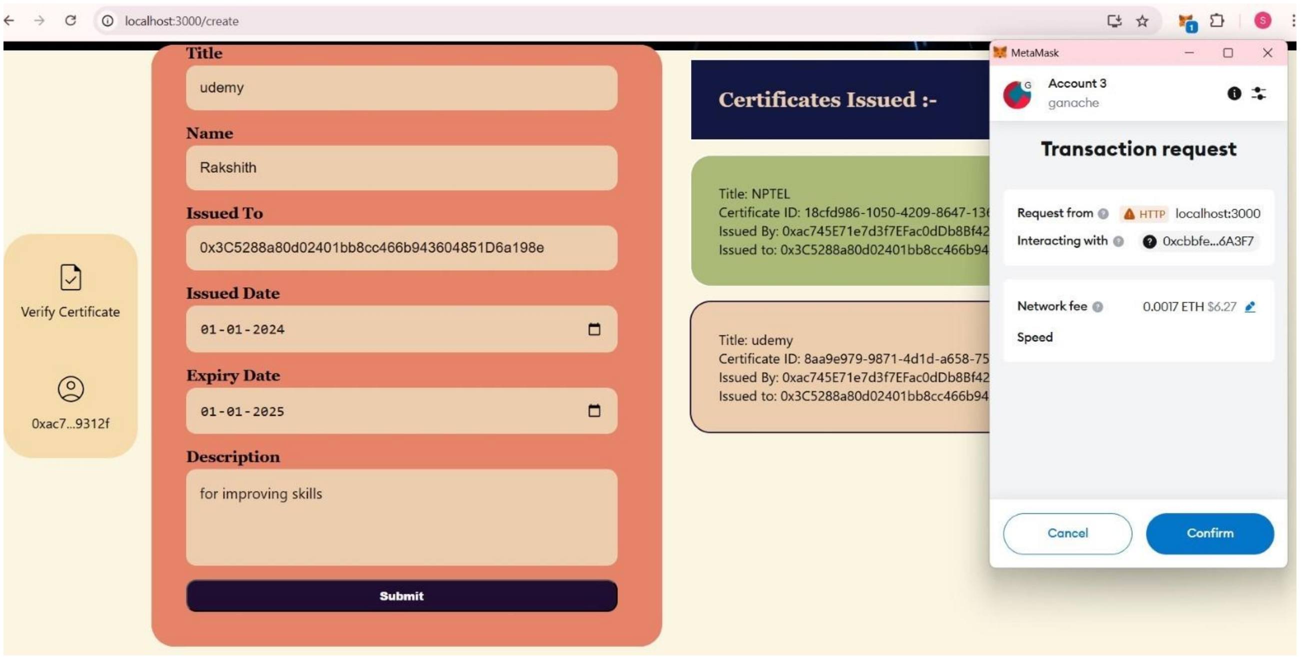
Description: By Swayam

Certificates Issued :-

Title: NPTEL
Certificate ID: 18cfd986-1050-4209-8647-136f75e6ea84
Issued By: 0xac745E71e7d3f7EFac0dDb8Bf42C891fFA79312f
Issued to: 0x3C5288a80d02401bb8cc466b943604851D6a198e

Title: udemy
Certificate ID: 8aa9e979-9871-4d1d-a658-75718037bd14
Issued By: 0xac745E71e7d3f7EFac0dDb8Bf42C891fFA79312f
Issued to: 0x3C5288a80d02401bb8cc466b943604851D6a198e

Fig.4.1.5 Certificate Issued



localhost:3000/create

Verify Certificate

0xac7...9312f

Title: udemy

Name: Rakshith

Issued To: 0x3C5288a80d02401bb8cc466b943604851D6a198e

Issued Date: 01-01-2024

Expiry Date: 01-01-2025

Description: for improving skills

Certificates Issued :-

Title: NPTEL
Certificate ID: 18cfd986-1050-4209-8647-13
Issued By: 0xac745E71e7d3f7EFac0dDb8Bf42
Issued to: 0x3C5288a80d02401bb8cc466b94

Title: udemy
Certificate ID: 8aa9e979-9871-4d1d-a658-75
Issued By: 0xac745E71e7d3f7EFac0dDb8Bf42
Issued to: 0x3C5288a80d02401bb8cc466b94

MetaMask

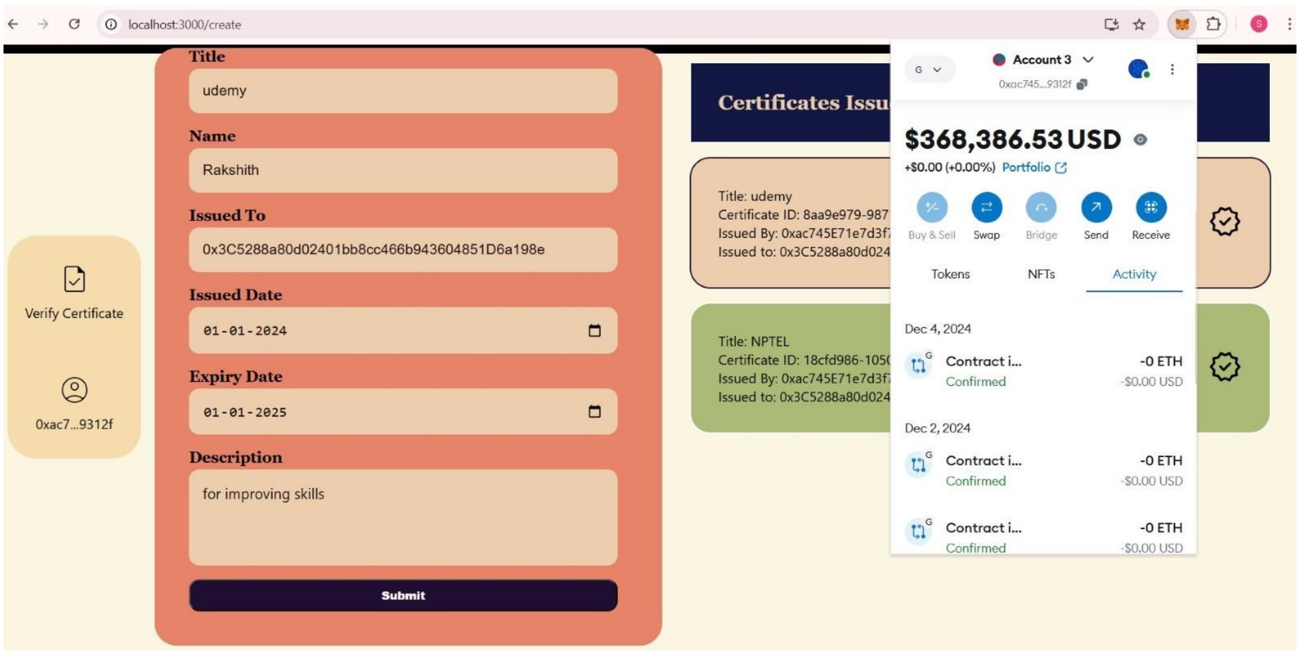
Account 3
ganache

Transaction request

Request from HTTP localhost:3000
Interacting with 0xcbbfe...6A3F7

Network fee 0.0017 ETH $6.27
Speed

Fig.4.1.6 Transaction Request



Title
udemy
Name
Rakshith
Issued To
0x3C5288a80d02401bb8cc466b943604851D6a198e
Issued Date
01-01-2024
Expiry Date
01-01-2025
Description
for improving skills

Title: udemy
Certificate ID: 8aa9e979-987
Issued By: 0xac745E71e7d3f7
Issued to: 0x3C5288a80d024

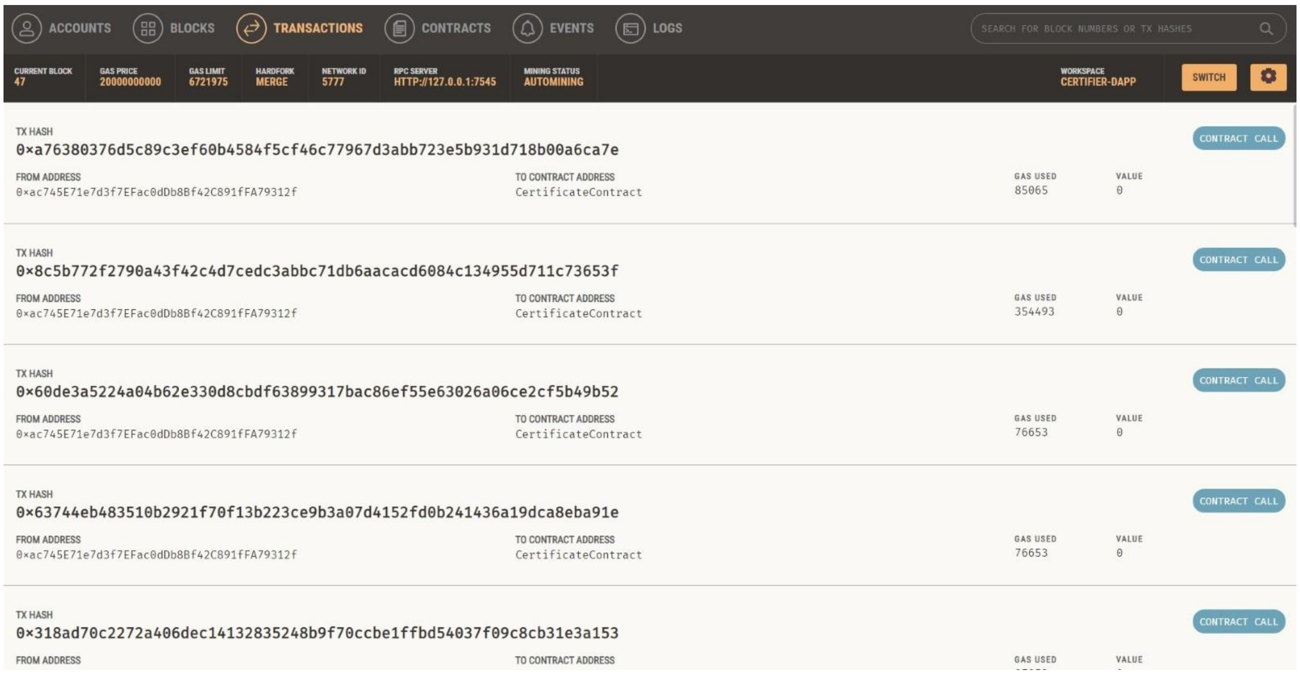
Title: NPTEL
Certificate ID: 18cfd986-105(
Issued By: 0xac745E71e7d3f7
Issued to: 0x3C5288a80d024

$368,386.53 USD
+$0.00 (+0.00%) Portfolio

Dec 4, 2024
Contract i... Confirmed -0 ETH -$0.00 USD

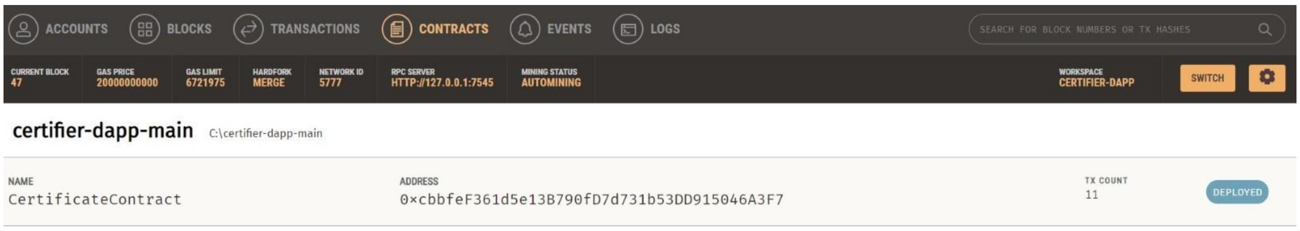
Dec 2, 2024
Contract i... Confirmed -0 ETH -$0.00 USD
Contract i... Confirmed -0 ETH -$0.00 USD

Fig.4.1.7 Transaction Confirmation



```
CURRENT BLOCK  GAS PRICE    GAS LIMIT  HARDFORK  NETWORK ID  RPC SERVER              MINING STATUS   WORKSPACE
47             20000000000  6721975    MERGE     5777        HTTP://127.0.0.1:7545   AUTOMINING      CERTIFIER-DAPP

TX HASH
0x a76380376d5c89c3ef60b4584f5cf46c77967d3abb723e5b931d718b00a6ca7e
FROM ADDRESS                                   TO CONTRACT ADDRESS     GAS USED   VALUE
0xac745E71e7d3f7EFac0dDb8Bf42C891fFA79312f     CertificateContract     85065      0

TX HASH
0x8c5b772f2790a43f42c4d7cedc3abbc71db6aacacd6084c134955d711c73653f
FROM ADDRESS                                   TO CONTRACT ADDRESS     GAS USED   VALUE
0xac745E71e7d3f7EFac0dDb8Bf42C891fFA79312f     CertificateContract     354493     0

TX HASH
0x60de3a5224a04b62e330d8cbdf63899317bac86ef55e63026a06ce2cf5b49b52
FROM ADDRESS                                   TO CONTRACT ADDRESS     GAS USED   VALUE
0xac745E71e7d3f7EFac0dDb8Bf42C891fFA79312f     CertificateContract     76653      0

TX HASH
0x63744eb483510b2921f70f13b223ce9b3a07d4152fd0b241436a19dca8eba91e
FROM ADDRESS                                   TO CONTRACT ADDRESS     GAS USED   VALUE
0xac745E71e7d3f7EFac0dDb8Bf42C891fFA79312f     CertificateContract     76653      0

TX HASH
0x318ad70c2272a406dec14132835248b9f70ccbe1ffbd54037f09c8cb31e3a153
FROM ADDRESS                                   TO CONTRACT ADDRESS     GAS USED   VALUE
```

Fig.4.1.8 Transaction Preview in Ganache

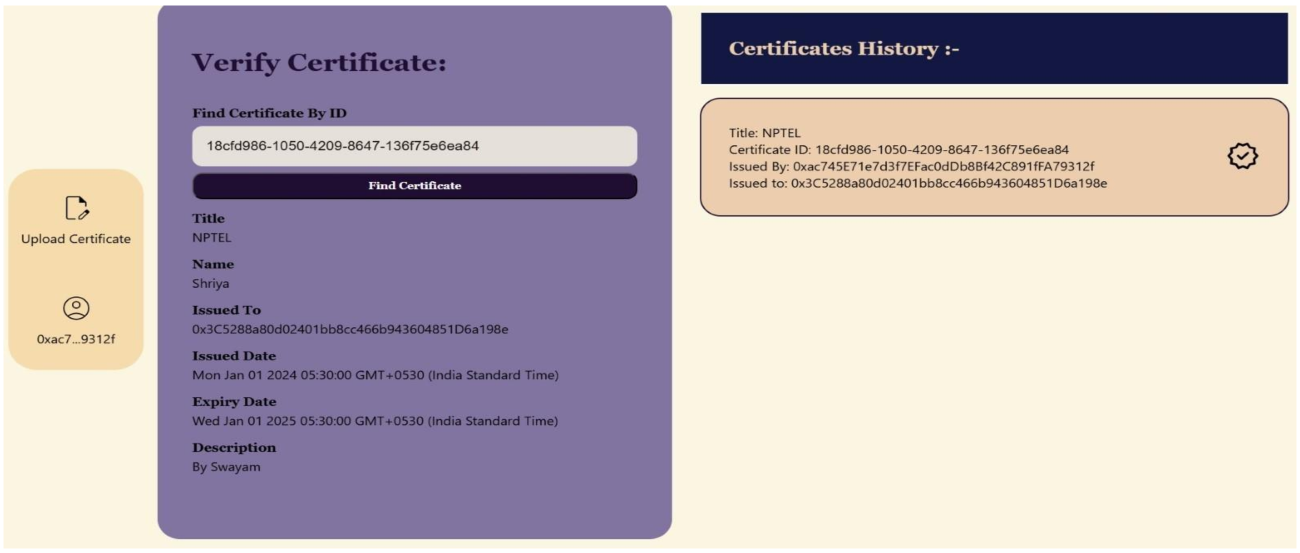


CURRENT BLOCK 47 | GAS PRICE 20000000000 | GAS LIMIT 6721975 | HARDFORK MERGE | NETWORK ID 5777 | RPC SERVER HTTP://127.0.0.1:7545 | MINING STATUS AUTOMINING | WORKSPACE CERTIFIER-DAPP

certifier-dapp-main C:\certifier-dapp-main

NAME CertificateContract
ADDRESS 0×cbbfeF361d5e13B790fD7d731b53DD915046A3F7
TX COUNT 11

Fig.4.1.9 Deployed Smart Contract



Verify Certificate:

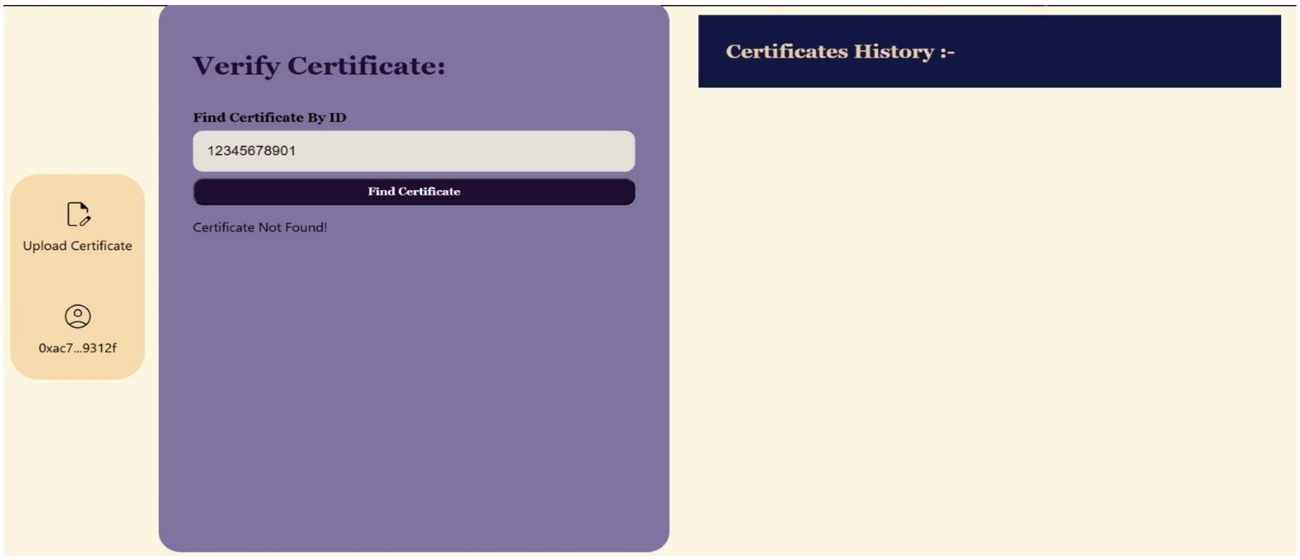
Find Certificate By ID
18cfd986-1050-4209-8647-136f75e6ea84

Title
NPTEL
Name
Shriya
Issued To
0x3C5288a80d02401bb8cc466b943604851D6a198e
Issued Date
Mon Jan 01 2024 05:30:00 GMT+0530 (India Standard Time)
Expiry Date
Wed Jan 01 2025 05:30:00 GMT+0530 (India Standard Time)
Description
By Swayam

Certificates History :-

Title: NPTEL
Certificate ID: 18cfd986-1050-4209-8647-136f75e6ea84
Issued By: 0xac745E71e7d3f7EFac0dDb8Bf42C891fFA79312f
Issued to: 0x3C5288a80d02401bb8cc466b943604851D6a198e

Fig.4.1.10 Verification of Valid Certificate



Verify Certificate:

Find Certificate By ID
12345678901

Certificate Not Found!

Certificates History :-

Fig.4.1.11 Verification of Invalid Certificate

4.2 Analysis of Result

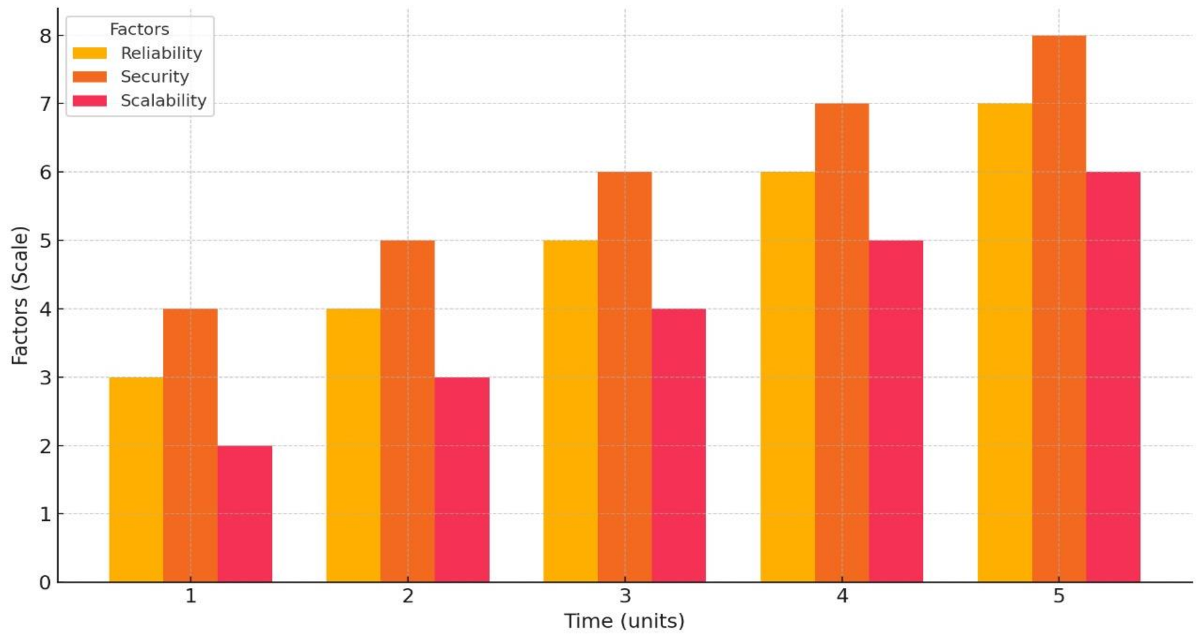


Fig 4.2.1 Factors over time in Blockchain-Based Certificate Verification System

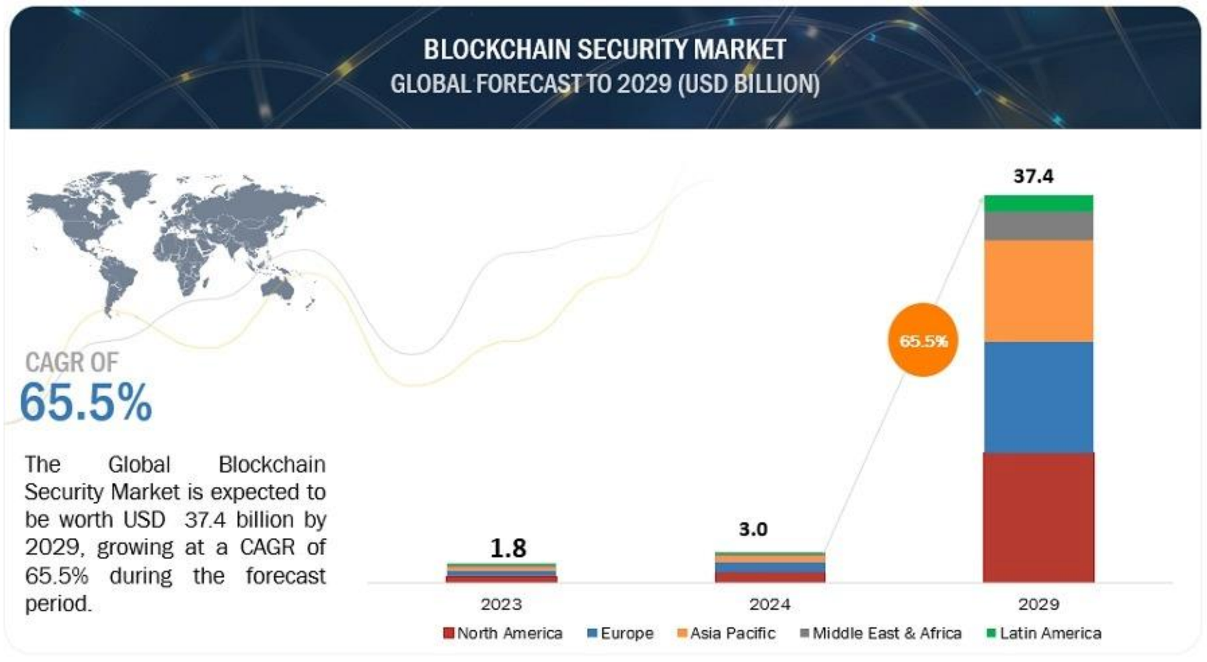


Fig 4.2.2 Global Forecast to 2029(in USD)

The fig 4.2.2 shows the significant growth of the Blockchain Security Market, expected to reach USD 37.4 billion by 2029 with a CAGR of 65.5%. This growth reflects the increasing adoption of blockchain technology for secure and transparent systems, emphasizing its potential in applications like certificate verification to reduce fraud and enhance trust.

4.3 Comparison with Expectations

The Blockchain-Based Certificate Verification System met its primary objectives of providing secure, tamper-proof certificate verification through blockchain technology, ensuring the integrity of certificate data and enabling automated verification processes. The system fulfilled the expectation of decentralization, enhancing trust by removing the need for a central authority.

However, several aspects did not fully align with expectations. The requirement for a stable internet connection for blockchain interactions limits offline access to certificate verification. Additionally, the management of large certificate files required reliance on off-chain storage solutions, adding complexity to the system. Blockchain transaction speeds also impacted performance, especially when dealing with high volumes of certificates. While the system improved security through blockchain, further enhancements are needed in areas such as user authentication, role-based access control, and data encryption.

In summary, while the system successfully met its key goals of security, transparency, and decentralization, there is a need for optimization in performance, scalability, and security features for broader application.

Chapter 5

CONCLUSION

5.1 Summary of Findings

The Blockchain-Based Certificate Verification System demonstrated significant potential in revolutionizing the process of verifying educational and professional credentials. By leveraging blockchain technology, the system provided a secure, immutable, and efficient method for certificate issuance and verification. The system successfully ensured data integrity, eliminated risks associated with fraud, and simplified the process for users and institutions alike. The use of blockchain for decentralized storage allowed for instant verification of credentials, and the transparency of the system fostered trust among employers, educational institutions, and other stakeholders. However, areas for future development were identified to further improve its effectiveness. These include enhanced privacy features and addressing challenges related to system scalability and user adoption.

5.2 Limitations

- **Scalability Challenges:** As the number of certificates increases, blockchain networks may slow down, causing delays in verification.
- **Transaction Costs:** Using public blockchains involves transaction fees. With a high volume of verifications, these fees can significantly raise operational costs.
- **Data Privacy Risks:** Storing sensitive information on a public blockchain can expose it to privacy issues unless it is well-encrypted.
- **Storage Constraints:** Blockchains have limited space for large data sets, so off-chain storage solutions are needed for certificates, which adds complexity to the system.
- **User Experience Barriers:** Blockchain technology can be difficult for non-technical users to understand and use, requiring extensive training and support

5.3 Future Work

Future improvements for the blockchain-based certificate verification system could include adding AI features to analyze and predict credential trends, enhancing security measures, and making the system compatible with different blockchain platforms for better scalability. Integrating with educational institutions and employers' databases could allow real-time updates and verification. Adding support for multiple languages and developing a mobile app would make the system more accessible. Real-time notifications about new verifications and updates would improve the user experience. Continuously improving the user interface would make the system easier to use. Implementing smart contracts could automate the verification process, reducing manual effort and increasing efficiency. Creating a blockchain-based audit trail of all transactions and verifications would enhance transparency and trust.

REFERENCES:

1. **Dinesh Kumar K, Senthil P, and Manoj Kumar D.S**, "Educational Certificate Verification System Using Blockchain," International Journal of Scientific & Technology, 2020.
2. **A. Gayathiri, J. Jayachitra, and S. Matilda**, "Certificate Validation Using Blockchain," in IEEE, 2020.
3. **Shivani Pathak, Vimal Gupta, Nitima Malsa, Ankush Ghosh**, "Blockchain-Based Academic Certificate Verification System," in Springer, 2022.
4. **Padmavati E. Gundgurti**, "Smart and Secure Certificate Validation System through Blockchain," in IEEE, 2020.
5. **Qurotul Aini, Eka Purnama Harahap, Nuke Puji Lestari Santoso, Siti Nurindah Sari**, "Blockchain Based Certificate Verification System Management," 2022
6. **Jiin-Chiou Cheng, Narn-Yih Lee, Chien Chi, and Yi-Hua Chen**, "Blockchain and Smart Contract for Digital Certificate," in IEEE, 2018.
7. **Ninda Lutfiani, Desy Apriani, Efa Ayu Nabila, and Hega Lutfilah Juniar**, "Academic Certificate Fraud Detection System Framework Using Blockchain Technology," B-Front, 2022.
8. **Giandari Maulani, Gunawan, Leli Nirmalasari, Efa Ayu Nabila, and Windy Yestina Sari** "Digital Certificate Authority with Blockchain Cybersecurity in Education," IJCITSM, 2021.
9. **Charles Kim and Fatima Rahman**, "Implementation of Blockchain for Academic Certificate Authentication," Journal of Computer Networks, 2020.
10. **Peter Johnson and Wei Zhang**, "Blockchain-Powered Verification of Educational Credentials," Computers & Security Journal, 2021.
11. **Kevin Roberts and Rina Gupta**, "Blockchain in Higher Education: Verification of Certificates," Educational Technology Journal, 2022.
12. **Michael S. Robinson and Clara Hernandez**, "Blockchain-Based Certificates in Professional Development and Skill Recognition," Journal of Blockchain Research and Development, 2023.