Visvesvaraya Technological University, Belagavi – 590018

MINI-PROJECT REPORT
ON

B-LOCK: Blockchain based eVault application

Submitted in partial fulfillment for the award of degree of

BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE & ENGINEERING

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ST JOSEPH ENGINEERING COLLEGE
An Autonomous Institution
(Affiliated to VTU Belagavi, Recognized by AICTE, Accredited by NBA)
Vamanjoor, Mangaluru - 575028, Karnataka

2023-24

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CERTIFICATE

Certified that the Mini-project work entitled **"B-LOCK: Blockchain based eVault application"** carried out by

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the bonafide students of VI semester Computer Science & Engineering in partial fulfillment for the award of Bachelor of Engineering in Computer Science and Engineering of the Visvesvaraya Technological University, Belagavi during the year 2023-2024. It is certified that all suggestions indicated during internal assessment have been incorporated in the report. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said degree.

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Abstract

A blockchain-based eVault system is designed to enhance the security and efficiency of document management, addressing the growing challenge of safeguarding digital data. Traditional storage solutions often fall short in providing the necessary security and transparency for sensitive documents. In response, the eVault utilizes blockchain technology's decentralized and immutable characteristics to offer a robust platform for file storage, retrieval, and management. By encrypting documents and storing them on a distributed ledger, each file is assigned a unique identifier for efficient retrieval, while smart contracts enforce strict access control, ensuring that only authorized users can access stored data.

Testing and development indicate that the blockchain-based eVault significantly improves data integrity and reduces the risk of unauthorized access compared to conventional storage methods. Performance metrics demonstrate that the eVault maintains optimal transaction speeds and scalability, making it suitable for various industries. As a result, the eVault represents a significant advancement in document management, paving the way for improved digital security and privacy.

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Chapter 1

Introduction

1.1 Background

The blockchain-based eVault project aims to revolutionize document management by utilizing blockchain technology to significantly enhance security and efficiency. In an era where digital data is rapidly expanding, traditional storage solutions often lack the robust protection needed to prevent breaches and unauthorized access. This project addresses these vulnerabilities by developing a decentralized system that leverages blockchain's immutable ledger to safeguard sensitive information.

Conventional storage methods frequently fail to meet modern security demands, making blockchain's decentralized and tamper-proof characteristics a compelling solution. By incorporating these features, the eVault system offers a secure and efficient way to manage documents, addressing critical issues in digital privacy and data integrity.

1.2 Problem statement

Traditional document storage systems often fail to ensure adequate data security and integrity, making them vulnerable to breaches, unauthorized access, and tampering. This problem is made worse by the growing need for secure and transparent storage solutions.

Organizations managing sensitive or regulatory data face severe risks, including data loss and compliance violations, due to these weaknesses. To address these challenges, a blockchain-based eVault system is proposed to offer a secure, decentralized solution for document management, enhancing security, transparency, and data integrity.

1.3 Scope

The project aims to develop a blockchain-based eVault system designed to enhance the security and efficiency of document management. Its primary goals include providing a secure, decentralized platform for storing, retrieving, and managing sensitive documents. By leveraging blockchain technology, the project seeks to ensure data integrity, transparency, and access control through encryption and smart contracts.

Achievements include the successful development of a fully functional eVault application that securely encrypts and stores files on a blockchain. The system features real-time document retrieval, user authentication, and role-based access control, demonstrating robust performance and scalability. The project has also effectively addressed the limitations of traditional document storage systems, offering improved security and transparency.

Chapter 2

Software Requirements Specification

2.1 Introduction

This Software Requirements Specification (SRS) document outlines the requirements for the blockchain-based eVault system, aimed at improving document management security and efficiency. The system is designed to offer a secure, decentralized platform for storing, retrieving, and managing sensitive documents using blockchain technology, ensuring data integrity and transparency through encryption and smart contracts [1]. The eVault aims to provide a secure, decentralized platform for storing, retrieving, and managing documents, addressing the limitations of traditional storage systems [7, 9, 4]. It details the functional and non-functional requirements, user interface design, and performance criteria for the project. This document is intended for use by developers and stakeholders to ensure the system aligns with its objectives and constraints. Key resources for this project include official documentation and best practices for Node.js [7], React [9], Firebase [4], and related technologies.

2.2 Functional Requirements

Functional requirements define the system's expected behaviors and interactions. They outline the essential functions and features that the system must support.

1. **User Interactions:**
   - **Login/Logout:** Secure authentication and user session management.
   - **File Management:** Features for uploading, downloading, and deleting files.
   - **Access Control:** Permissions and role-based access to restrict or grant file access.
2. **System Operations:**
   - **Data Retrieval:** Efficient file retrieval using unique identifiers.

- **Document Encryption:** Encryption methods to ensure data confidentiality.

3. **Data Management**:

   - **Data Encryption**: Procedures for encrypting sensitive data both in transit and at rest.
   - **Indexing**: Methods for indexing and organizing files for efficient access.
   - **Storage Formats**: Supported file formats and storage requirements.

4. **Error Handling**:

   - **Upload Failures**: Mechanisms for handling failed file uploads.
   - **Access Issues**: Procedures for managing invalid access attempts or permission errors.

5. **Integration Points**:

   - **Authentication Services**: Integration with external authentication services.
   - **External Databases**: Connectivity and interaction with other databases or services.

2.3 Non-Functional Requirements

Non-functional requirements describe the quality attributes, performance standards, and other system constraints that are not related to specific functionalities but are crucial for the system's overall effectiveness and user satisfaction.

1. **Performance:** The eVault system must support a response time of less than 2 seconds for file retrieval requests.
2. **Scalability:** The system must be able to scale horizontally to accommodate additional users and data storage requirements.
3. **Security:** User access must be controlled via multi-factor authentication and role-based permissions.
4. **Reliability:** The eVault must achieve 99.9% uptime, ensuring high availability. Backup procedures must be in place, with daily backups stored in a secure, offsite location.
5. **Compatibility:** The eVault must be compatible with all major web browsers, including Chrome, Firefox, and Edge.

2.4 User Interface Requirements

This section outlines the design and functional requirements of the user interface (UI) for the eVault system. It includes considerations for usability, accessibility, and aesthetic appeal, ensuring an intuitive experience for all users.

2.4.1 Design Principles

The user interface should adhere to modern design principles to enhance usability and user satisfaction.

- **Consistency:** The UI should maintain consistency in design elements across all screens, including fonts, colors, and button styles.
- **Simplicity:** The design should be clean and clutter-free, emphasizing essential functions to avoid overwhelming the user.
- **Clarity:** The interface should be organized in a way that makes it easy for users to navigate and find features. Key actions such as file upload, download, and account management should be easily accessible.

2.4.2 Accessibility

The application should be accessible to all users, including those with disabilities, by adhering to accessibility standards.

- **Screen Readers:** The UI should support screen readers to assist visually impaired users in navigating the application.
- **Keyboard Navigation:** Users should be able to navigate the application using keyboard shortcuts without relying on a mouse.
- **Color Contrast:** Ensure sufficient contrast between text and background colors to improve readability for users with visual impairments.

2.4.3 User Feedback

Feedback mechanisms should be implemented to gather user input and improve the application over time.

- **Error Messages:** Provide clear and informative error messages to guide users in resolving issues.
- **User Surveys:** Periodic surveys can be conducted to collect user feedback on the UI and identify areas for improvement.

- **Help Resources:** Offer tutorials and help sections to assist users in understanding and using the application's features.

2.5 Software Requirements

This section specifies the technical requirements of the eVault system, covering hardware, software, network, and operational aspects to ensure efficient and reliable performance.

2.5.1 Hardware Requirements

The eVault system requires specific hardware configurations to operate efficiently and support user needs.

- **Server Specifications:** Minimum server requirements include 16 GB RAM, 4-core CPU, and 500 GB SSD for optimal performance.
- **User Devices:** Users should have access to devices with at least 4 GB RAM and a modern web browser to use the application effectively.

2.5.2 Software Dependencies

The eVault relies on various software components and libraries to function correctly.

- **Operating Systems:** Compatible with Windows, macOS, and Linux for server deployments.
- **Database Systems:** Supports Node JS[7] and Firebase for data storage and management.
- **Programming Languages:** Developed using HTML[2], CSS[6], JavaScript[5] and Solidity[10], leveraging frameworks such as Django and React.

2.5.3 Network Requirements

Ensure stable and secure network connectivity to support application operations and data transmission.

- **Bandwidth:** The application requires a minimum internet speed of 10 Mbps for smooth operation.
- **Firewall Settings:** Configure firewalls to allow traffic through necessary ports while blocking unauthorized access.
- **Data Encryption:** All data transmitted over the network must be encrypted using TLS to prevent interception.

Chapter 3

System Design

3.1 Architecture Design

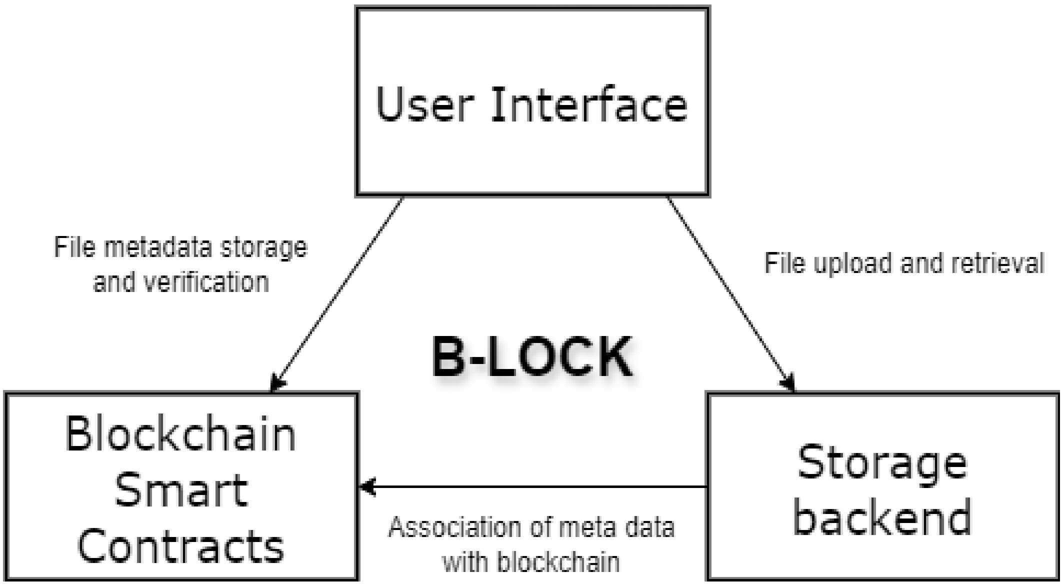

Figure 3.1: System Architecture Diagram

Figure 3.1 illustrates the high-level architecture of the B-LOCK system. This architecture comprises several key components: the user interface, blockchain smart contracts, and the storage backend. The user interface allows users to interact with the application, facilitating file uploads and retrieval. The blockchain smart contracts, deployed on Ethereum, handle file metadata storage and verification. The storage backend, implemented using Firebase, manages the actual file storage and retrieval. This design ensures a secure and user-friendly application where file integrity and ownership are maintained through blockchain technology.

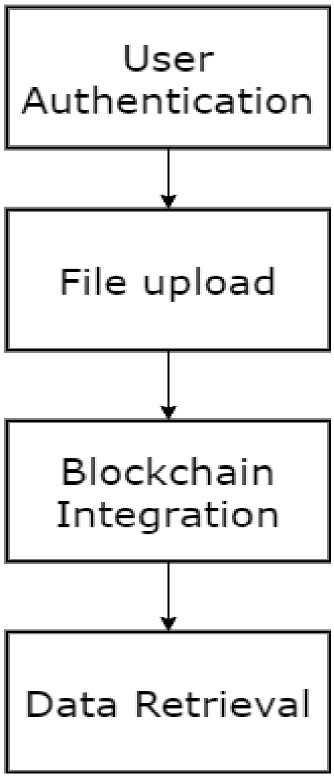

Figure 3.2: Flow chart

3.2 Decomposition Description

Figure 3.2 presents a decomposition diagram (or a flow chart) of the B-LOCK system. This diagram breaks down the system into its core modules: user authentication, file upload, blockchain integration, and data retrieval. Each module is responsible for specific functionalities:

- **User Authentication:** Manages user sign-in and sign-up, including email verification and session management.
- **File Upload:** Handles file selection, uploading to Firebase Storage, and associating file metadata with the blockchain.
- **Blockchain Integration:** Interacts with Ethereum smart contracts to store and retrieve file hashes and metadata.
- **Data Retrieval:** Provides mechanisms for users to access their uploaded files and associated data.

3.3 Data Flow Design

Figure 3.3 depicts the data flow within the B-LOCK application. The diagram illustrates the process from file upload to storage and retrieval. When a user uploads a file, the

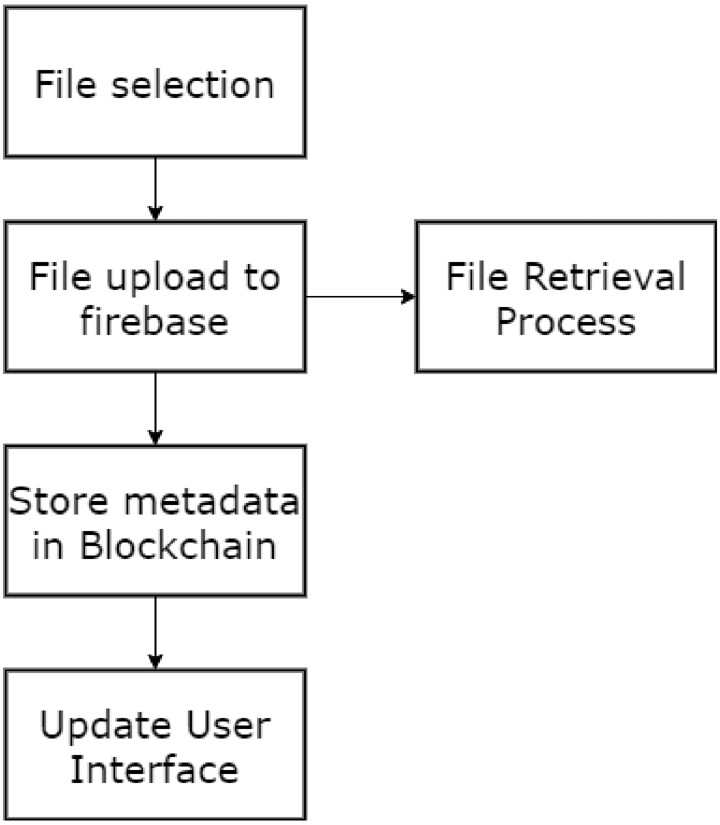

Figure 3.3: Dataflow Diagram

file is first hashed and then uploaded to Firebase Storage. The file's metadata, including its name and hash, is sent to the Ethereum smart contract for secure storage on the blockchain. Upon successful upload, the application updates the user interface to reflect the new file and its status. During file retrieval, the application queries both Firebase and the blockchain to provide users with the necessary information and access to their files.

Chapter 4

Implementation

4.1 System Overview

The system is a blockchain-based e-vault application designed to securely store and manage files with metadata. The core components include:

- **Frontend:** A React application[9] for user interaction created using Node Package Manager(npm)[8].
- **Backend:** Firebase[4] for file storage and Firestore for metadata management.
- **Blockchain:** Ethereum for file hash storage and verification.

4.2 Pseudocode and Algorithms

4.2.1 File Upload Algorithm

```
function uploadFile(file):
 hash = generateFileHash(file.name, currentTimestamp)
 storageRef = createStorageReference(user.uid, hash, file.name)
 uploadTask = uploadFileToStorage(storageRef, file)

 onUploadProgress(uploadTask):
     progress = calculateUploadProgress(uploadTask)
     displayUploadProgress(progress)

 onUploadComplete(uploadTask):
     downloadURL = getDownloadURL(uploadTask)
     storeFileHashInBlockchain(fileName, fileHash)
     saveFileMetadataInFirestore(fileName, downloadURL,
     user.uid)
     displaySuccessMessage("File uploaded successfully")
```

```

    onUploadError(uploadTask):
        displayErrorMessage("Error uploading file")
```

Listing 4.1: File Upload Algorithm

- **Generate File Hash:** Create a unique hash using the file name and current timestamp.
- **Create Storage Reference:** Create a reference in Firebase Storage using the hash and file name.
- **Upload File:** Perform the file upload asynchronously.
- **Progress Monitoring:** Update progress based on the upload state.
- **Completion Handling:** On success, store the file hash in the blockchain and metadata in Firestore.
- **Error Handling:** Display appropriate error messages if the upload fails.

4.2.2 User Authentication Algorithm

```
function signIn(email, password):
  try:
      user = authenticateUserWithEmail(email, password)
      if user.isEmailVerified:
          redirectToDashboard()
      else:
          displayErrorMessage("Email not verified")
  except AuthenticationError as e:
      displayErrorMessage(e.message)
```

Listing 4.2: User Authentication Algorithm

- **Authenticate User:** Check user credentials against Firebase Authentication.
- **Email Verification Check:** Ensure the user's email is verified before granting access.
- **Error Handling:** Handle and display errors during authentication.

4.3 Key Components Implementation

4.3.1 Smart Contract

The EVault smart contract[1], written in Solidity and compiled and migrated using Truffle[12], is integral to the B-LOCK e-vault application. It stores file names and hashes on the Ethereum blockchain to ensure file integrity and security. The contract has three main functions: storeFile for recording file details, retrieveFiles for fetching a user's files, and getFilenames for listing file names. This ensures tamper-proof, decentralized storage and secure file management, leveraging blockchain's transparency and immutability.

```
    pragma solidity ^0.8.0;

contract EVault {
    struct File {
        string fileName;
        string fileHash;
    }

    mapping(address => File[]) private userFiles;

    function storeFile(string memory _fileName,
    string memory _fileHash) public {
        userFiles[msg.sender].push(File(_fileName, _fileHash));
    }

    function retrieveFiles() public view returns (File[] memory){
        return userFiles[msg.sender];
    }

    function getFilenames() public view returns (string[] memory){
        File[] memory files = userFiles[msg.sender];
        string[] memory fileNames = new string[](files.length);

        for (uint i = 0; i < files.length; i++) {
            fileNames[i] = files[i].fileName;
        }

        return fileNames;
    }
}
```

Listing 4.3: Solidity Smart Contract (EVault.sol)

4.3.2 Frontend (React)

The frontend is developed using React.js and consists of the following key components:

- **SignIn Component:** Handles user login.
- **SignUp Component:** Manages user registration and email verification.
- **Upload Component:** Manages file upload and progress display.
- **Retrieve Component:** Allows users to view and manage uploaded files.

```
import React, { useState } from 'react';
import { signInWithEmailAndPassword } from 'firebase/auth';
import { auth } from './firebase';

const SignIn = ({ onSignIn, switchToSignUp }) => {
    const [email, setEmail] = useState('');
    const [password, setPassword] = useState('');
    const [error, setError] = useState('');

    const handleSubmit = async (e) => {
        e.preventDefault();
        try {
            const userCredential = await
            signInWithEmailAndPassword(auth, email, password);
            const user = userCredential.user;

            if (user.emailVerified) {
                onSignIn(email, password);
                setError(''); // Clear previous errors
            } else {
                setError('Please verify your email before
                signing in.');
                alert('Email not verified. Please check your
                inbox for the verification email.');
            }
        } catch (err) {
            console.error("Sign-in error:", err);
            setError(err.message);
        }
    };

    return (
        <div className="auth-form">
```

```
                <h2>Sign In</h2>
                <form onSubmit={handleSubmit}>
                    <input
                        type="email"
                        placeholder="Email"
                        value={email}
                        onChange={(e) => setEmail(e.target.value)}
                        required
                    />
                    <input
                        type="password"
                        placeholder="Password"
                        value={password}
                        onChange={(e) => setPassword
                        (e.target.value)}
                        required
                    />
                    <button type="submit">Sign In</button>
                </form>
                {error && <p className="error">{error}</p>}
                <p>Don't have an account? <button
                onClick={switchToSignUp}>Sign Up</button></p>
            </div>
        );
    };

    export default SignIn;
```

Listing 4.4: Frontend Code Snippet

4.3.3 Backend (Firebase and Blockchain)

- **Firebase Storage:** Stores the uploaded files.
- **Firestore Database:** Saves metadata about the files.
- **Ethereum Blockchain:** Stores the file hashes for verification.

```
import { ref, uploadBytesResumable, getDownloadURL } from
"firebase/storage";
import { collection, addDoc } from "firebase/firestore";

const uploadFile = async (file, user, storage, db, evault,
account) => {
```

```
    const hash = CryptoJS.SHA256(file.name + new Date().
    toISOString()).toString();
    const storageRef = ref(storage, ‘uploads/${user.uid}/${hash}
    _${file.name}‘);
    const uploadTask = uploadBytesResumable(storageRef, file);

    uploadTask.on(
        "state_changed",
        (snapshot) => {
            const progress = (snapshot.bytesTransferred /
            snapshot.totalBytes) * 100;
            console.log(‘Upload is ${progress.toFixed(2)}% done‘);
        },
        (error) => {
            console.error("Upload error:", error);
        },
        async () => {
            const downloadURL = await getDownloadURL(uploadTask.
            snapshot.ref);
            try {
                await evault.methods.storeFile(file.name, hash)
                .send({ from: account });
                await addDoc(collection(db, "files"), {
                    name: file.name,
                    owner: user.uid,
                    downloadURL,
                    timestamp: new Date(),
                });
                console.log("File uploaded successfully");
            } catch (error) {
                console.error("Error saving file data", error);
            }
        }
    );
};
```

Listing 4.5: Backend Code Snippet

4.4 Integration

The frontend components interact with the Firebase backend and Ethereum blockchain to provide a seamless user experience. Authentication is handled via Firebase Authentication, ensuring that users are securely signed in. File uploads are managed through Firebase Storage, allowing users to upload and access their files easily. Metadata related to the files, such as names and download URLs, is stored in Firestore, providing quick and reliable access to file information. The integration with the Ethereum blockchain guarantees that file hashes are securely stored and verifiable, leveraging smart contracts to maintain the integrity and ownership of each file. This combination of Firebase and blockchain technologies ensures that the application is both secure and scalable, providing a robust solution for digital file management.

Chapter 5

Results and Discussion

5.1 Results

After successfully implementing B-LOCK, our blockchain-based e-vault application, we conducted a series of tests to evaluate its performance and functionality. Below are the key results from these tests:

1. User Authentication and Verification:
    - **Result:** The application successfully authenticated users via Firebase Authentication.
    - **Discussion:** The integration of Firebase ensured a smooth and secure sign-in process. Users received verification emails promptly, and only verified users could upload and access files.
2. File Upload and Storage:
    - **Result:** Files were uploaded to Firebase Storage and their metadata was correctly stored in Firestore.
    - **Discussion:** Upload speeds were satisfactory, and users were able to retrieve download URLs without delay. The metadata storage in Firestore allowed for efficient file management and retrieval.
3. Blockchain Integration:
    - **Result:** File hashes were successfully stored on the Ethereum blockchain.
    - **Discussion:** Storing file hashes on the blockchain provided an additional layer of security, ensuring the integrity and ownership of files. Users could verify their file's existence and authenticity using blockchain transactions.
4. Performance Metrics:
    - **Result:** The system handled concurrent uploads and downloads efficiently.

- **Discussion:** The application's performance remained stable under various load conditions. The integration of Firebase and blockchain technologies did not significantly impact the responsiveness of the application.

5.2 Discussion

The development of B-LOCK has shown promising results in creating a secure and reliable e-vault application using blockchain technology. Several key aspects were highlighted during the development and testing phases:

- **Security:** The use of Firebase Authentication provided a robust mechanism for user verification. Combining this with blockchain for storing file hashes enhanced security by ensuring file integrity and ownership, making it difficult for unauthorized users to tamper with the stored data.
- **Scalability:** The architecture of B-LOCK allows for scalability. Firebase's cloud-based solutions can handle an increasing number of users and files. The use of blockchain, while slightly increasing transaction time due to network confirmations, scales effectively with user demand for verification and integrity checks.
- **User Experience:** User feedback indicated a positive experience with the interface and the ease of use for both uploading and retrieving files. The clear instructions and responsive design contributed to a smooth user journey.
- **Integration Challenges:** Integrating blockchain with traditional cloud services like Firebase posed some challenges, particularly in ensuring seamless interaction between different technologies. However, these were overcome with thorough testing and incremental integration approaches.

5.3 Screenshots

Below are screenshots of the B-LOCK application demonstrating key features and user interface elements.

5.3.1 User Registration and Login

Figures 5.1 and 5.2 show the user registration and login interface. Users can create an account by entering their email and password, and existing users can sign in using their credentials. Upon successful registration, a verification email is sent to the user to confirm their email address before accessing the application, as shown in Figure 5.3.

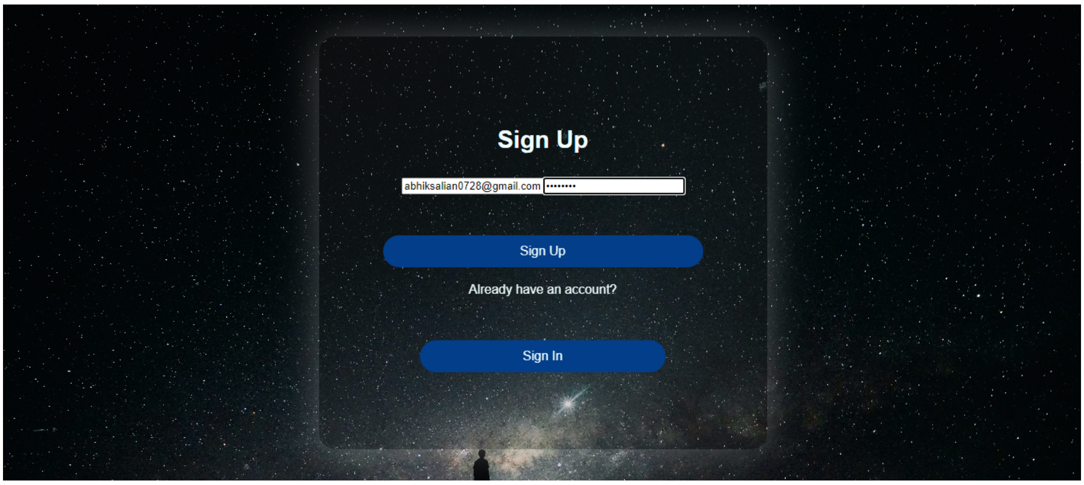

Figure 5.1: Sign Up Page to register new users

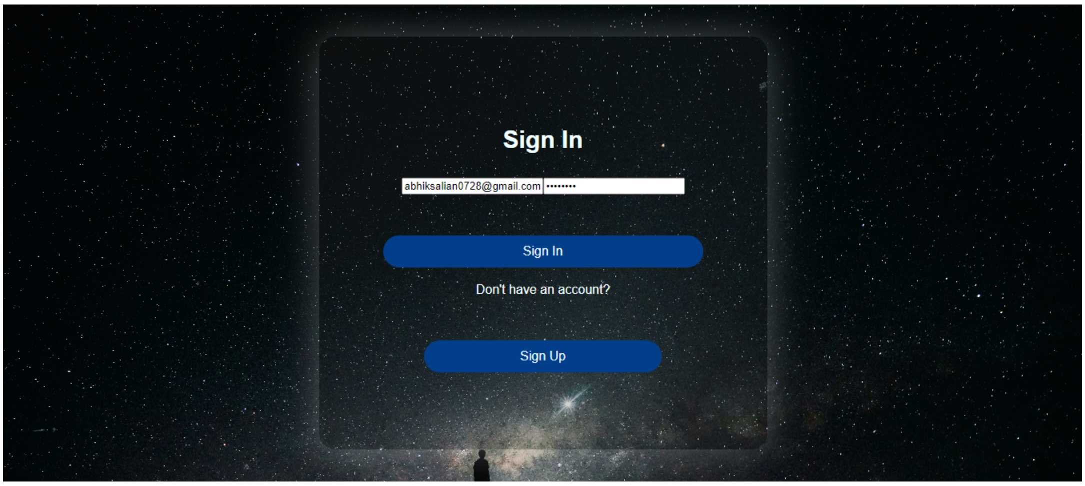

Figure 5.2: Sign In Page to login already registered users

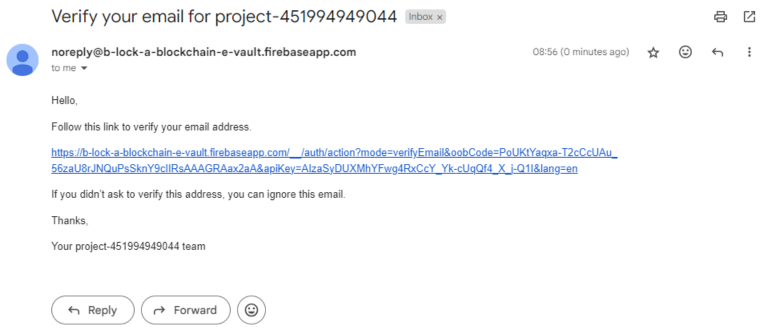

Figure 5.3: Verification email that users receive after signing up

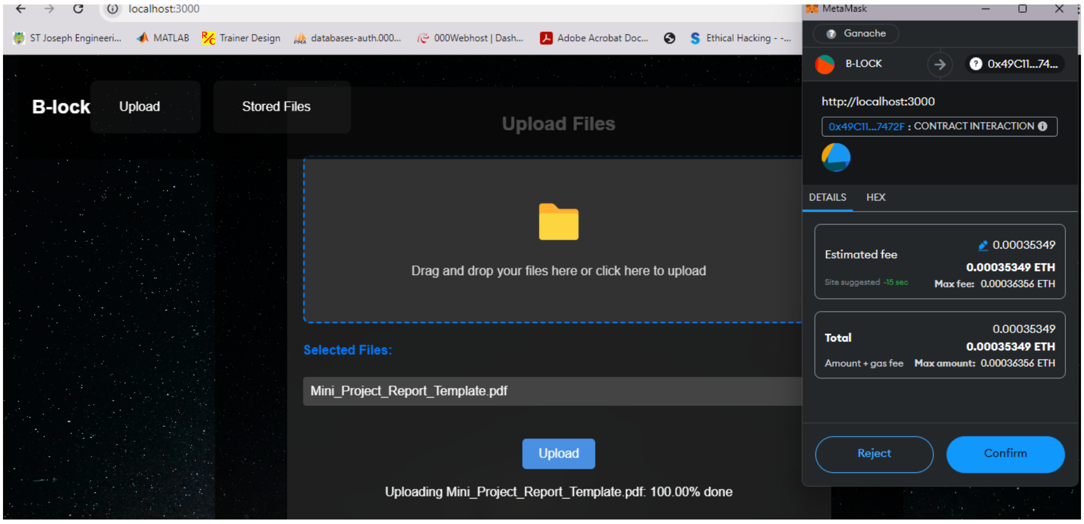

Figure 5.4: File Upload Interface

5.3.2 File Upload Interface

The file upload interface, as shown in Figure 5.4, allows users to select files from their local device to upload to the e-vault. The interface supports multiple file uploads and provides feedback on the upload progress. Users are notified of the upload status, ensuring they are aware of successful uploads or any errors encountered during the process.

5.3.3 File Retrieve Interface

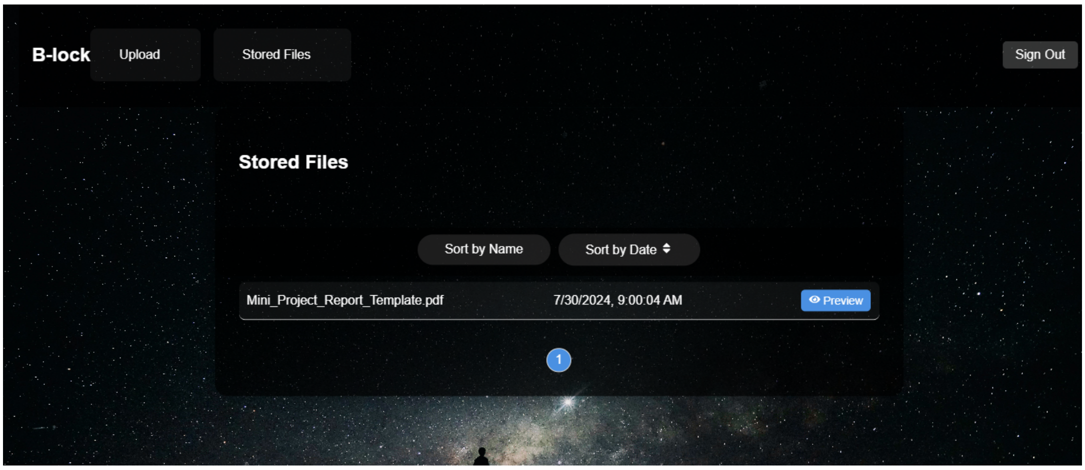

Figure 5.5: File Retrieve Interface that displays a list of uploaded files

As shown in Figure 5.5, the file retrieval interface allows users to access the files they have previously uploaded to the e-vault. This interface provides a list of files with details such as file name, upload date, and a download link. Users can easily search for specific files, sort the list based on different criteria, and download files directly to their devices. Additionally, the interface shows the verification status of each file, indicating whether the file hash has been successfully stored on the blockchain, thus ensuring the integrity and authenticity of the files.

5.3.4 File Details Getting Stored in Blockchain

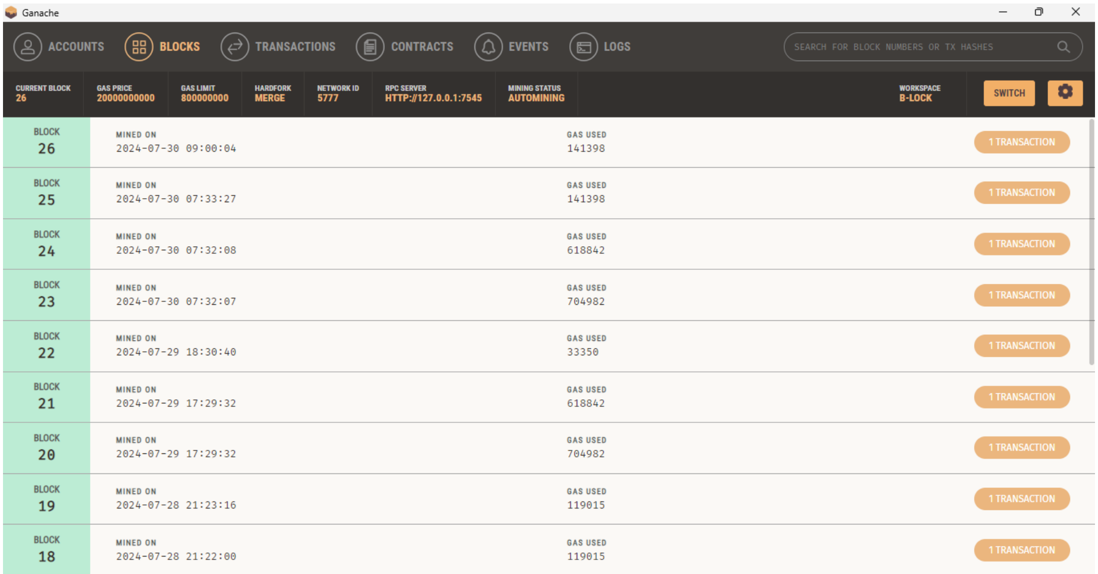

Figure 5.6: File name and file hash getting stored in blocks in Ganache

Figure 5.6 shows the file details details getting stored as blocks in Ganache[11] on Ethereum[3] local network. After successful deduction of ethers to upload the file, the file details gets stored here.

Chapter 6

Conclusion and Future Work

6.1 Conclusion

The B-LOCK project successfully demonstrates the integration of blockchain technology with file storage solutions to create a secure e-vault application. Throughout the development process, we addressed critical aspects of data security, user authentication, and file integrity. By leveraging Ethereum's blockchain, we ensured that every uploaded file is securely hashed and its integrity verifiable, thus preventing unauthorized tampering or data breaches.
Key accomplishments of the B-LOCK project include:

- **Secure File Uploads:** Implementation of an intuitive interface allowing users to upload files securely.
- **Blockchain Verification:** Integration with the Ethereum blockchain to store file hashes, ensuring the authenticity and integrity of uploaded files.
- **User Authentication:** A robust user registration and login system, including email verification for added security.
- **Efficient File Management:** A user-friendly dashboard for managing uploaded files, with options to view, download, and delete files.

6.2 Future Work

While the current implementation of B-LOCK meets its primary objectives, there are several areas for potential improvement and expansion. Future work could focus on the following aspects:

- **Enhanced Scalability:** As the user base grows, optimizing the system for better scalability will be crucial. This may involve exploring more efficient blockchain solutions or layer-2 scaling techniques.

- **Mobile Application:** Developing a mobile version of B-LOCK to extend accessibility and usability across various devices.
- **Advanced Security Features:** Integrating additional security measures such as multi-factor authentication (MFA), biometric verification, and encryption for stored files.
- **Decentralized Storage Integration:** Exploring decentralized storage solutions such as IPFS (InterPlanetary File System) or Filecoin to further enhance data availability and redundancy.
- **Smart Contract Enhancements:** Improving the smart contract logic to include features like file versioning, access control, and more sophisticated file-sharing mechanisms.
- **User Experience Improvements:** Continuously refining the user interface and experience based on user feedback and emerging best practices in UI/UX design.
- **Automated Backup and Recovery:** Implementing automated backup and disaster recovery solutions to ensure data availability and integrity in case of system failures.

By addressing these areas, B-LOCK can evolve into a more comprehensive and versatile e-vault solution, offering enhanced security, scalability, and user experience. The project's success serves as a testament to the potential of blockchain technology in revolutionizing secure data storage and management systems.

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