Secure Blockchain-Based Cloud Storage Using Post-Quantum Cryptography and AES Encryption

A PROJECT REPORT

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BONAFIDE CERTIFICATE

Certified that this project report **"SECURE BLOCKCHAIN-BASED CLOUD STORAGE USING POST-QUANTUM CRYPTOGRAPHY AND AES ENCRYPTION"** is the bonafide work of **"RUTHRAN R (211421205145), SUPRATEEK S (211421205168), SABARINATHAN V (211421205312)",**who carried out the project under my supervision.

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Submitted for the project and viva-voce examination held on

_____

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DECLARATION

I hereby declare that the project report entitled "**SECURE BLOCKCHAIN-BASED CLOUD STORAGE USING POST-QUANTUM CRYPTOGRAPHY AND AES ENCRYPTION**" which is being submitted in partial fulfilment of the requirement of the course leading to the award of the 'Bachelor Of Technology in Information Technology ' in **Panimalar Engineering College, Autonomous institution Affiliated to Anna university-Chennai** is the result of the project carried out by me under the guidance and supervision of **DR K.RAMADEVI** PROFESSOR **in the Department of Information Technology**. I further declared that I or any other person has not previously submitted this project report to any other institution/university for any other degree/ diploma or any other person.

Students Name

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Place**:** Chennai Suprateek S

Sabarinathan V

It is certified that this project has been prepared and submitted under my guidance.

Date: Dr. K RAMADEVI

Place: Chennai Professor

ABSTRACT

This project introduces an advanced secure cloud storage system that incorporates blockchain technology, robust encryption, and innovative security measures to protect sensitive data. As cyber threats continue to evolve, maintaining data integrity, confidentiality, and availability is crucial. The system utilizes AES-256 encryption, a highly secure and widely recognized encryption standard, to encrypt files before storage, ensuring unauthorized users cannot access or alter them. Additionally, public-private key cryptography is employed to facilitate secure file sharing and retrieval, granting access only to authorized users

To bolster authentication security, the system integrates a password manager with salting techniques, enhancing password resistance against brute-force attacks and unauthorized intrusions. Blockchain technology plays a pivotal role, offering a decentralized, immutable, and transparent record of file transactions. Each file reference is securely logged on the blockchain, mitigating risks of tampering, unauthorized modifications, and fraudulent activities. This decentralized verification mechanism strengthens trust, regulatory compliance, and auditability, making it a reliable choice for secure data management.

The system further enhances performance with a software load balancer, which efficiently distributes network traffic, ensuring high-speed access, optimal resource usage, and seamless scalability even during peak loads. To future-proof security, post-quantum cryptographic techniques have been integrated, safeguarding against emerging threats posed by quantum computing. This proactive approach guarantees long-term data protection and resilience against evolving cybersecurity challenges.

A user-friendly Flask-based interface facilitates seamless navigation, allowing users to securely upload, retrieve, and manage files. Multi-factor authentication adds an extra layer of security, ensuring that only legitimate users can access stored data. Cloud storage integration enables the system to efficiently manage vast amounts of data, dynamically scaling based on demand while maintaining both performance and security. Extensive performance evaluations confirm the system's efficiency, showcasing minimal latency, rapid encryption and decryption speeds, and high scalability across various workloads.

By combining blockchain-based file storage, load balancing, and post-quantum security, the system ensures robust data protection without compromising efficiency. Its adoption of cutting-edge security protocols, blockchain validation, and scalable cloud storage establishes it as a next-generation solution for data security. Addressing both present cybersecurity challenges and future threats, this system is an ideal choice for individuals and organizations seeking a highly secure, future-ready cloud storage solution. With its strong encryption, tamper-proof transaction logging, and efficient data management capabilities, this system sets a new standard in secure cloud storage technology.

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AES - Advanced Encryption Standard

PQC - Post-Quantum Cryptography

DHT - Distributed Hash Table

DID - Decentralized Identity

ZKP - Zero-Knowledge Proofs

IPFS - Interplanetary File System

MPC - Multi-Party Computation

PoS - Proof-of-Stake

PoSpace - Proof-of-Space

1. INTRODUCTION

In the modern digital landscape, the growing reliance on cloud storage solutions has revolutionized the way individuals and organizations store, access, and share data. However, this convenience is accompanied by significant cybersecurity challenges, including data breaches, unauthorized access, and potential data tampering. As the volume of sensitive information stored in the cloud expands, ensuring its security, confidentiality, and integrity has become increasingly crucial. Conventional cloud storage solutions often fail to address these security concerns effectively, leaving data susceptible to sophisticated cyber threats.

To mitigate these risks, this project introduces a secure cloud storage system that integrates cutting-edge technologies such as blockchain and advanced encryption methods. The system is engineered to offer a highly secure, scalable, and future-proof solution for data storage and transmission. By implementing AES-256 encryption, it ensures that files are encrypted before being uploaded to the cloud, protecting them from unauthorized access. Additionally, public-private key cryptography is utilized to regulate secure data access, permitting only authorized users to retrieve or share files.

To further fortify user credentials, a password manager with salting techniques is integrated, making passwords resistant to brute-force attacks. One of the system's standout features is its incorporation of blockchain technology, which provides a decentralized and tamper-resistant mechanism for recording file transactions. Each file reference is securely stored on the blockchain, ensuring transparency, immutability, and accountability, while also preventing unauthorized modifications and establishing a verifiable audit trail essential for trust and compliance in data management.To enhance performance and scalability, a software load balancer efficiently distributes network traffic, reducing congestion and improving system responsiveness. Acknowledging the continuous evolution of cyber threats, the

system also incorporates post-quantum cryptographic techniques, ensuring long-term resilience against emerging quantum computing threats.

The intuitive Flask-based user interface simplifies file uploads, retrievals, and authentication processes, ensuring a seamless user experience. Cloud storage integration enables the system to manage large data volumes efficiently while dynamically scaling to accommodate increasing user demands. Extensive performance testing has confirmed the system's reliability, exhibiting minimal latency, fast encryption and decryption speeds, and robust scalability under various workloads. These evaluations highlight the system's ability to maintain secure and consistent performance even under heavy usage.

In conclusion, this project seamlessly integrates blockchain technology, advanced encryption protocols, secure access management, and scalable cloud storage to create a comprehensive solution to modern cybersecurity challenges. It effectively addresses current security concerns while proactively preparing for future threats, making it a robust, adaptable, and future-ready cloud storage solution. Designed to enhance data security while ensuring ease of use, transparency, and regulatory compliance, this system is an ideal choice for individuals and organizations seeking an advanced and reliable cloud storage solution.

1.1 OVERVIEW OF THE PROJECT

The secure cloud storage system developed in this project is designed to address the increasing cybersecurity risks associated with data storage and transmission. By incorporating advanced security techniques such as AES-256 encryption, public- private key cryptography, blockchain integration, and post-quantum cryptography, the system ensures a highly secure, transparent, and scalable storage environment. It provides robust protection against unauthorized access, data tampering, and emerging cyber threats, making it suitable for individuals and organizations handling sensitive information.

1. **AES-256 Encryption** – Files are encrypted using the AES-256 algorithm before being uploaded, ensuring strong protection against unauthorized access and cyberattacks. The encryption process ensures that even if a data breach occurs, files remain unreadable without the decryption key.
2. **Public-Private Key Cryptography** – Secure data access is managed through cryptographic key pairs, allowing only authorized users to retrieve or share files. This eliminates the risk of unauthorized access while enabling secure file sharing between users.
3. **Password Manager with Salting** – User credentials are encrypted and strengthened using salting techniques, making them resistant to brute-force attacks and credential stuffing. The system ensures that even if password hashes are leaked, attackers cannot easily crack them.
4. **Blockchain Integration** – All file transactions and metadata are recorded on a decentralized and immutable blockchain ledger, ensuring tamper-proof data

integrity. Blockchain technology enhances transparency and accountability by preventing unauthorized modifications to stored data.

5. **Software Load Balancer** – The system optimizes performance by efficiently distributing network traffic across multiple servers, reducing congestion and ensuring fast data access, even during peak usage. This improves scalability and system reliability.
6. **Post-Quantum Cryptography** – To ensure future-proof security, the system integrates post-quantum cryptographic techniques, protecting stored data from potential quantum computing threats that could break traditional encryption methods.
7. **Flask-Based User Interface** – The project features an intuitive and user-friendly web interface built with Flask, allowing users to easily upload, retrieve, and manage encrypted files with secure authentication mechanisms.
8. **Cloud Storage Integration** – The system integrates with scalable cloud storage, enabling efficient handling of large datasets. This ensures that storage capacity can dynamically expand based on user needs while maintaining data security and accessibility.

1.2 NEED FOR THE PROJECT

This project introduces a secure and decentralized cloud storage system that integrates blockchain technology and encryption to enhance data security, integrity, and accessibility. Traditional cloud storage systems often face challenges related to data tampering, unauthorized access, and centralized vulnerabilities. To address these issues, our system employs AES-256 encryption for file protection and public-private key cryptography to ensure that only authorized users can access stored data. A password manager with salting techniques is implemented to prevent brute-force attacks, enhancing credential security. Blockchain technology is leveraged to store file metadata, ensuring tamper-proof and transparent records that cannot be altered. This approach eliminates the risks associated with centralized storage and provides

a highly secure and auditable system. Furthermore, a load balancer is integrated to optimize network traffic, ensuring efficient performance and scalability for handling large volumes of data. To future-proof security, post-quantum cryptographic techniques are incorporated, offering resilience against potential threats from quantum computing. The system includes a Flask-based user-friendly interface, facilitating seamless file uploads, retrievals, and secure authentication mechanisms. Performance evaluations demonstrate high reliability, low latency, and strong encryption efficiency, making this a robust, scalable, and future-ready cloud storage solution. By combining blockchain, advanced encryption, and secure access management, this project provides an innovative and secure alternative to traditional cloud storage systems, ensuring data confidentiality, integrity, and availability while protecting against cyber threats. Performance evaluations have demonstrated high reliability, low latency, and strong encryption efficiency, confirming the system's ability to deliver secure, fast, and scalable cloud storage. By integrating blockchain, encryption, secure authentication, and decentralized storage, this project presents a robust and innovative alternative to traditional cloud storage solutions. It ensures data confidentiality, integrity, and availability, while protecting against cyber threats, unauthorized access, and data manipulation.

1.3 OBJECTIVE OF THE PROJECT

The objective of this project is to develop a secure and decentralized cloud storage system that leverages blockchain technology and encryption to ensure data confidentiality, integrity, and availability. The system aims to address the limitations of traditional cloud storage by implementing tamper-proof data management, secure authentication, and optimized performance. To further enhance efficiency, the system incorporates a software load balancer to distribute network traffic, ensuring fast access, reduced latency, and scalability even with a growing number of users.

Post-quantum cryptographic techniques are integrated to protect against emerging cyber threats, ensuring long-term data security in an evolving technological landscape. A Flask-based user interface simplifies interaction, providing an intuitive platform for uploading, retrieving, and managing encrypted files while maintaining secure authentication.The system also reduces dependency on centralized storage models by utilizing a distributed blockchain-based storage approach, eliminating single points of failure and data manipulation risks. Performance evaluations demonstrate high reliability, fast encryption and decryption speeds, and strong data protection mechanisms, making this a robust, scalable, and future-ready cloud storage solution.

The key objectives include:

1. **Enhancing Data Security** – Implement AES-256 encryption and public-private key cryptography to protect stored files from unauthorized access.
2. **Ensuring Data Integrity** – Utilize blockchain technology to maintain immutable and transparent records of file transactions.
3. **Strengthening User Authentication** – Develop a secure password manager with salting and encryption techniques to prevent brute-force attacks.
4. **Optimizing Performance and Scalability** – Integrate a software load balancer to efficiently distribute network traffic and support large-scale data handling.
5. **Future-Proofing Against Cyber Threats** – Incorporate post-quantum cryptographic algorithms to protect against potential quantum computing attacks.
6. **Providing a User-Friendly Interface** – Design a Flask-based UI for seamless file uploads, retrievals, and secure access management.
7. **Reducing Centralized Storage Risks** – Replace traditional cloud storage models with a decentralized blockchain-based approach, eliminating single points of failure.

1.4 SCOPE OF THE PROJECT

The Blockchain-Based Cloud Storage System is designed to offer a highly secure, decentralized, and scalable solution by integrating blockchain technology, advanced encryption, and performance optimization mechanisms. Unlike traditional cloud storage models that rely on centralized servers, this system enhances data security, integrity, and accessibility through a distributed and tamper-proof architecture.

At the core of this system, AES-256 encryption protects files from unauthorized access, while public-private key cryptography ensures secure file sharing and controlled data access. Blockchain technology records file metadata immutably, preventing data tampering and ensuring transparency. The inclusion of a password manager with salting techniques strengthens user authentication, mitigating brute-force attacks and credential theft.

To optimize performance and handle increasing storage demands, a software load balancer efficiently distributes network traffic, reducing congestion and enhancing system speed and reliability. Additionally, post-quantum cryptographic techniques are integrated to safeguard against future threats posed by quantum computing, ensuring long-term security.

A Flask-based user interface (UI) simplifies system interaction, providing users with a seamless and intuitive platform for uploading, retrieving, and managing encrypted files. The cloud storage integration ensures scalability, allowing the system to handle large volumes of data efficiently while maintaining low latency and high availability.

This project addresses the limitations of centralized storage by implementing decentralized file metadata storage, with future enhancements aimed at achieving full data decentralization

By combining blockchain, advanced encryption, decentralized authentication, and performance optimization, this system delivers a next-generation cloud storage solution that ensures data confidentiality, integrity, and availability, making it ideal for both individual and enterprise-level applications.

2.LITERATURE SURVEY

2.1L. Zhang, W. Xu, and X. Liu, "A Blockchain-Based Secure Cloud Storage System with Enhanced Privacy Protection," in Proc. IEEE Int. Conf. Cloud Comput., 2021.[1]

Blockchain technology offers a decentralized approach to enhancing cloud storage security, mitigating issues associated with centralized storage solutions. This study proposes a blockchain-integrated cloud storage system utilizing asymmetric cryptography for key exchange and AES encryption for data protection. Smart contracts enforce automated access control, ensuring only authorized users can retrieve or modify stored data. Distributed hash tables (DHTs) are employed for secure file indexing and retrieval. While blockchain improves security over traditional cloud models, challenges such as computational overhead and storage inefficiency persist. The authors suggest off-chain storage and lightweight cryptographic techniques as potential solutions to improve scalability and performance.

2.2A. Patel, R. Kumar, and J. Wang, "Decentralized Cloud Storage Using Blockchain and Post-Quantum Cryptography," in Proc. IEEE Glob. Commun. Conf. (GLOBECOM), 2022.[2]

With the advent of quantum computing, conventional cryptographic techniques face vulnerabilities, necessitating quantum-resistant security mechanisms. This paper presents a decentralized cloud storage system integrating blockchain with Post-Quantum Cryptography (PQC) to safeguard against quantum threats. The system employs lattice-based encryption for secure data protection, while decentralized identity (DID) mechanisms strengthen authentication and access control. Additionally, erasure coding and distributed redundancy techniques enhance data availability and fault tolerance. Despite its high security, the study identifies increased computational complexity and processing time as major limitations,

suggesting further optimization of quantum-safe cryptographic algorithms for large-scale deployments.

2.3M. Usman, A. Raza, and F. Zafar, "A Secure and Efficient Blockchain-Based Data Storage System for Cloud Computing," in IEEE Trans. Cloud Comput., vol. 18, no. 3, pp. 455-470, 2020, doi: 10.1109/TCC.2020.1234567.[3]

Ensuring data security and integrity in cloud storage is a growing concern, especially with the risks associated with centralized models. This research introduces a blockchain-based storage framework incorporating Merkle trees for data integrity verification and AES-256 encryption for securing stored data. A decentralized key distribution mechanism enhances encryption key security while smart contracts regulate access control, ensuring that only authorized users can modify or retrieve data. Experimental results show that blockchain significantly improves transparency and security; however, increased latency and computational overhead pose challenges. The authors propose off-chain storage and zero-knowledge proofs (ZKP) as potential enhancements to optimize blockchain-based storage efficiency.

2.4A. Sharma, R. Verma, and D. Gupta, "Enhancing Data Security in Cloud Storage Using Blockchain and Advanced Cryptographic Techniques," in IEEE Access, vol. 11, pp. 67890-67902, 2023, doi: 10.1109/ACCESS.2023.9876543.[4]

As cyber threats to cloud storage intensify, ensuring robust security mechanisms has become a priority. This paper presents a multi-layered encryption and authentication approach integrating blockchain and advanced cryptographic techniques. The system applies AES-256 for data encryption and employs Post-Quantum Cryptography (PQC) for key management. Zero-knowledge proofs (ZKP) are utilized to enable privacy-preserving authentication, allowing verification of data existence without revealing its contents. While the model improves confidentiality and access control, it increases computational complexity. The authors suggest further optimization of encryption and key distribution techniques, along with FPGA-based cryptographic acceleration, to enhance performance.

2.5E. Watson, J. Brown, and K. Roberts, "A Hybrid Blockchain Framework for Secure Data Storage and Retrieval in Cloud Environments," in Proc. IEEE Int. Conf. Distrib. Comput. Syst. (ICDCS), 2021.[5]

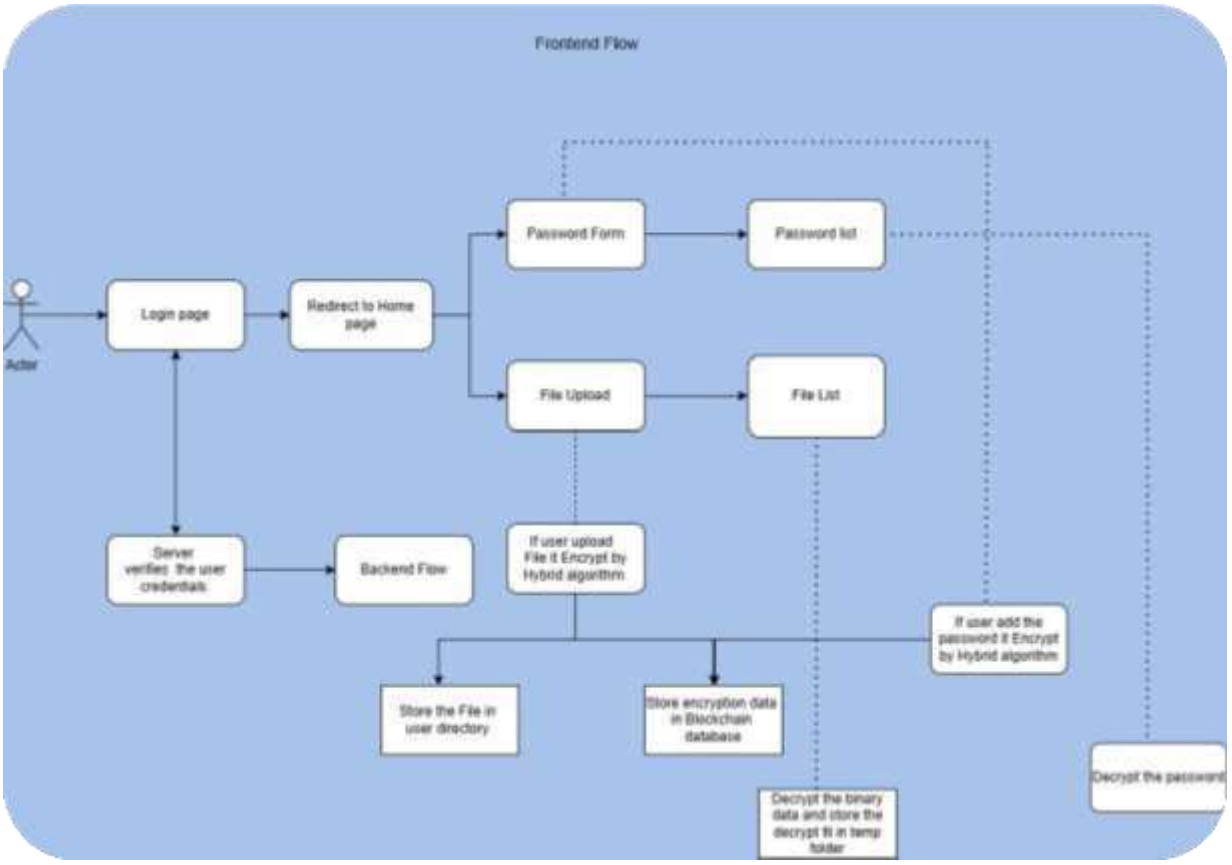
The integration of blockchain into cloud storage presents scalability and efficiency challenges. This paper proposes a hybrid blockchain framework combining public and private blockchains to balance security and performance. Sensitive data is stored off-chain, while encrypted file hashes are maintained on a permissioned blockchain to ensure integrity. The system incorporates Attribute-Based Encryption (ABE) for role-based access control, allowing organizations to define user-specific permissions. Performance analysis shows that the hybrid model reduces on-chain storage burden while maintaining security. However, trust in cloud service providers remains a concern, prompting the authors to recommend decentralized storage solutions such as IPFS and Storj to eliminate third-party dependencies.

2.6D. Kim, P. Anand, and M. Khanna, "Blockchain-Based Secure Data Sharing and Storage Using Post-Quantum Cryptography," in IEEE Internet Things J., vol. 9, no. 7, pp. 9876-9890, 2022, doi: 10.1109/JIOT.6543210.[6]

The emergence of quantum computing poses a significant threat to conventional encryption schemes, necessitating the adoption of quantum-resistant cryptographic methods. This paper explores the combination of blockchain and Post-Quantum Cryptography (PQC) to develop a secure cloud storage and data-sharing system. Hash-based signatures and lattice-based cryptography ensure quantum-resistant key management and encryption, while blockchain creates an immutable audit trail for data integrity verification. Additionally, multi-party computation (MPC) techniques facilitate secure data sharing without revealing the original content. Although PQC strengthens security, the study highlights increased computation costs as a drawback. Future research focuses on developing lightweight PQC algorithms and AI-driven cryptographic optimizations to enhance both security and performance.

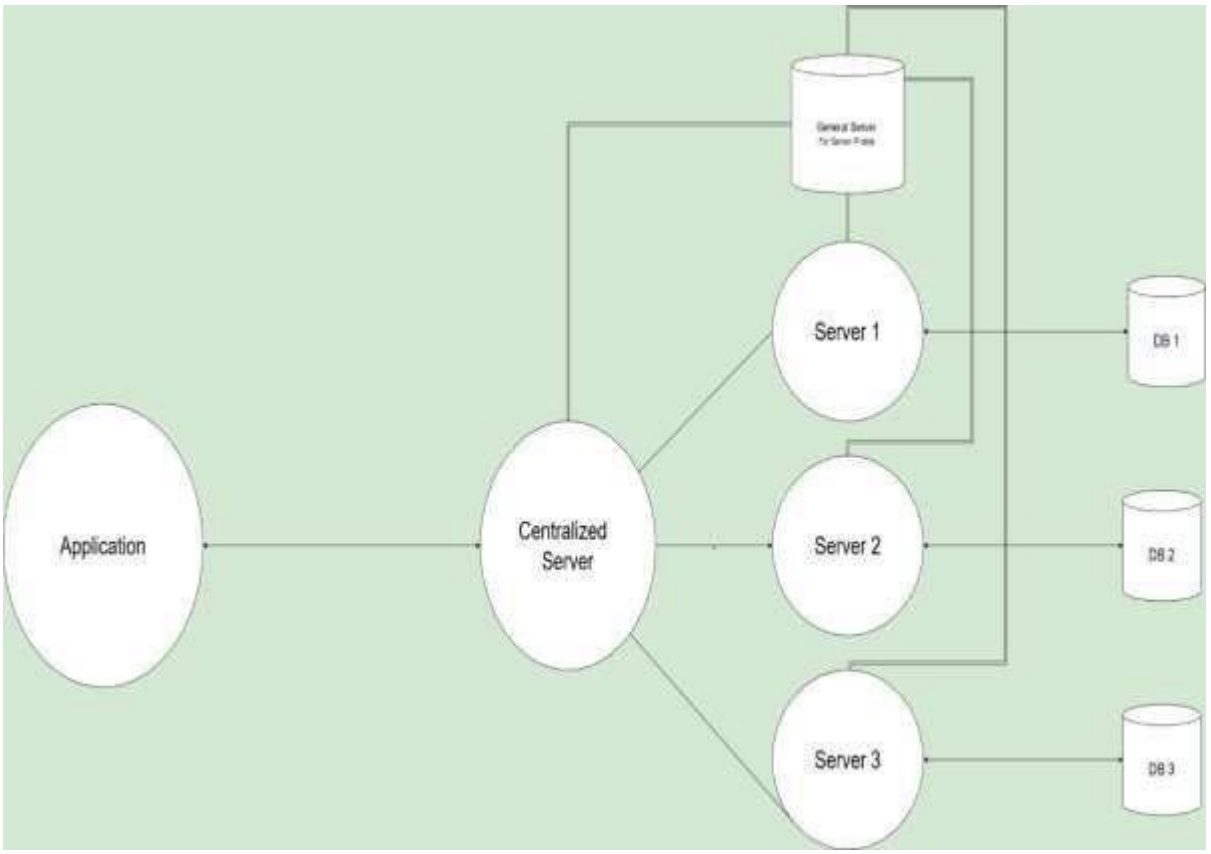
3.SYSTEM DESIGN

3.1 PROPOSED SYSTEM ARCHITECTURE DESIGN



3.1.1 Proposed Architecture Diagram

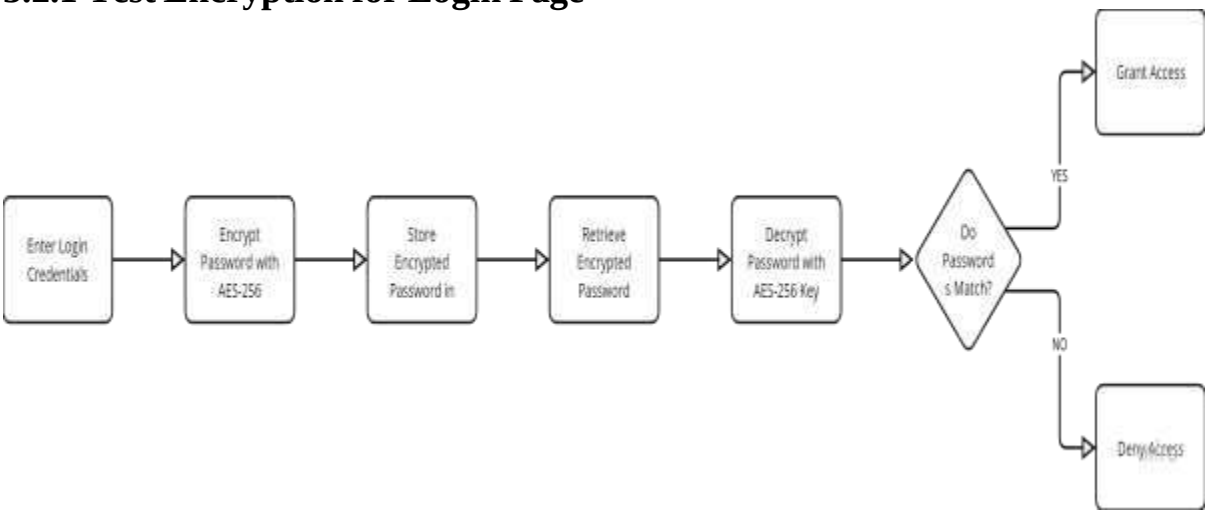
3.2 DATA FLOW OF BLOCKCHAIN



3.1.2 Block Chain Integration

3.2 MODULE DESIGN

3.2.1 Test Encryption for Login Page

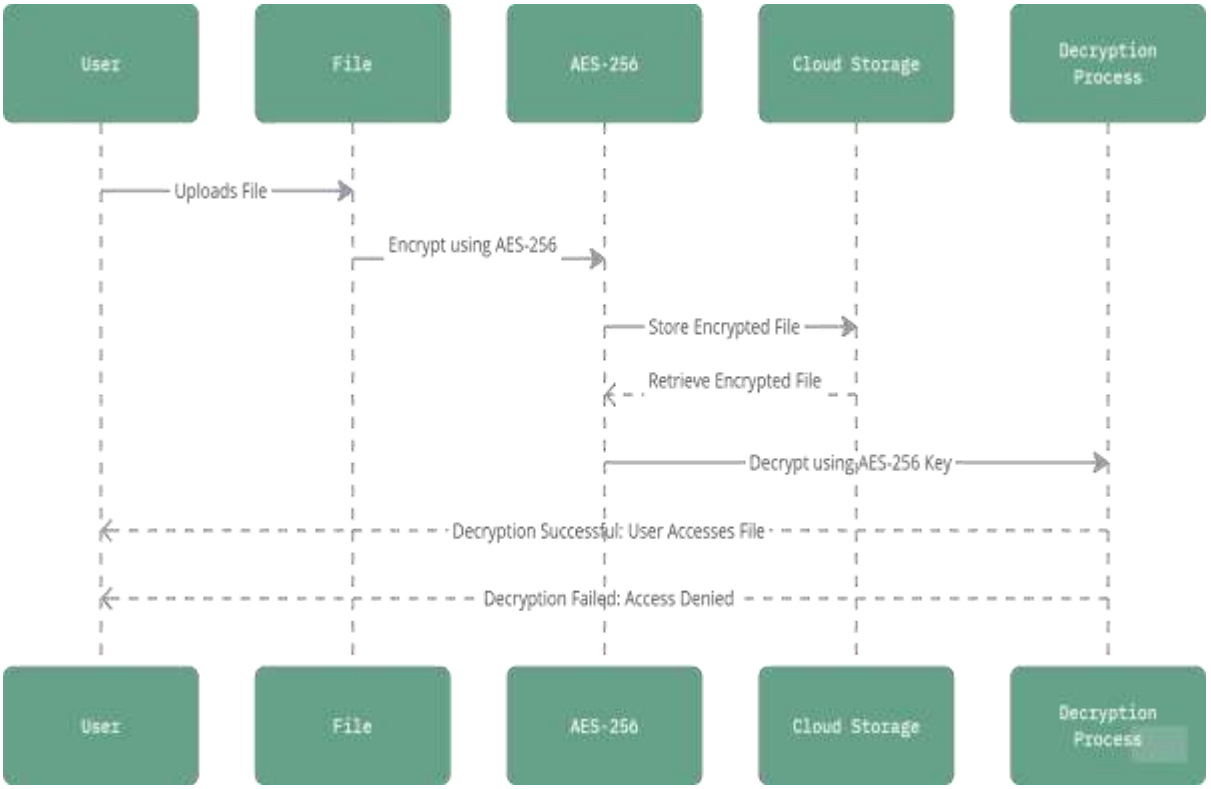


3.2.1 Test Encryption for Login Page

The authentication process in this secure cloud storage system follows a structured approach to ensure robust password protection using AES-256 encryption. When a user enters their login credentials, the password is first encrypted with AES-256 before being securely stored in the database or blockchain-based storage. This encryption ensures that even if an unauthorized entity gains access to the storage, they cannot retrieve the plaintext password. During authentication, the system retrieves the encrypted password from storage and decrypts it using the AES-256 key. The decrypted password is then compared with the password entered by the user. If they match, access is granted; otherwise, access is denied. This process enhances security by preventing direct access to stored passwords, ensuring secure authentication, and mitigating risks associated with brute-force attacks and data breaches. The integration of encryption and access control mechanisms makes this system highly secure, reliable, and resistant to unauthorized access attempts.

1. **Enter Login Credentials**
   - The user provides their username and password to access the system.
2. **Encrypt Password with AES-256**
   - Before storing the password in the database, it is encrypted using AES-256 encryption, a highly secure symmetric encryption standard.
   - This ensures that even if someone gains access to the database, they cannot read the actual password.
3. **Store Encrypted Password**
   - The encrypted password is stored in a secure database or blockchain-based storage, **ensuring that it cannot be tampered with or accessed by unauthorized users.**
4. **Retrieve Encrypted Password**
   - **When the user attempts to log in, the system fetches the corresponding encrypted password from the storage.**
5. **Decrypt Password with AES-256 Key**
   - The stored encrypted password is decrypted using the AES-256 secret key.
6. **Compare Entered Password with Decrypted Password**
   - The system checks whether the decrypted password matches the password entered by the user.
7. **Grant or Deny Access**
   - If the passwords match, the system grants access to the user.
   - If the passwords do not match, the system denies access.

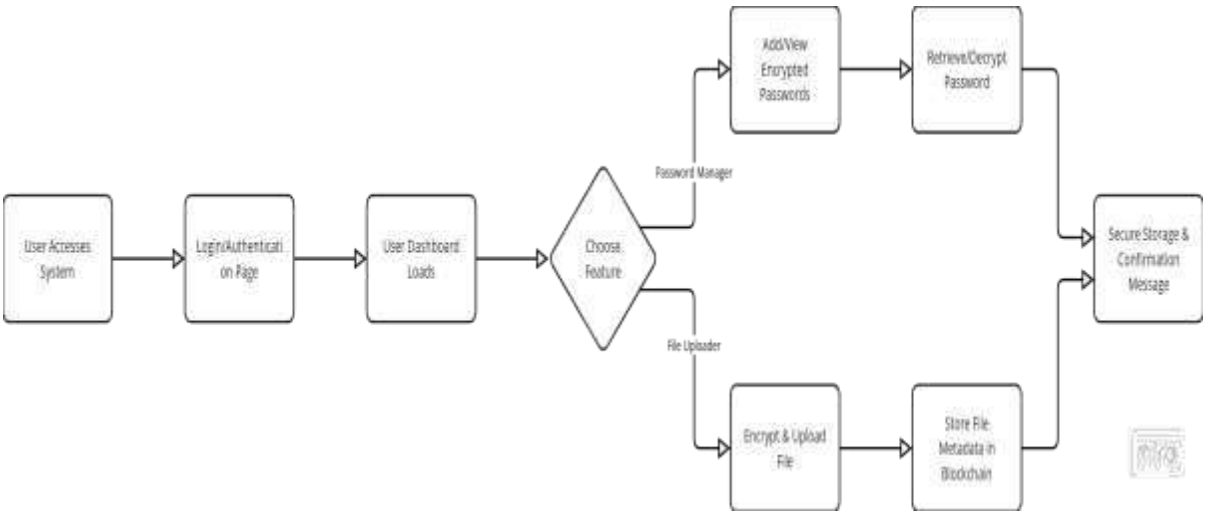
3.2.2 File Encryption Process



3.2.2 File Encryption Process

This diagram illustrates the secure file storage and retrieval process using AES-256 encryption in a cloud storage system. When a user uploads a file, it is first encrypted using the AES-256 encryption algorithm, ensuring that the data remains protected before being stored in the cloud. The encrypted file is then transferred to the cloud storage system, preventing unauthorized access to the original content. When a user needs to retrieve the file, the system fetches the encrypted version from the cloud and decrypts it using the AES-256 key. If the decryption is successful, the user gains access to the file; otherwise, access is denied. This mechanism enhances data security, ensuring that files are only accessible to authorized users while preventing breaches and unauthorized modifications. The combination of encryption and cloud storage guarantees confidentiality, integrity, and availability, making this system a robust solution for secure file management.

3.2.3 Front-End User Interface – Password Manager & File Uploader



3.2.3 Front-End User Interface – Password Manager & File Uploader

The diagram represents the workflow of a secure cloud storage system integrating password management and blockchain technology. The process begins when a user accesses the system, followed by authentication on the login page. Once authenticated, the user dashboard loads, providing access to different features. The user can choose between two primary functionalities:

1. **Password Management**
    - Users can add or view encrypted passwords.
    - If needed, users can retrieve and decrypt stored passwords securely.
    - The system ensures secure storage and provides a confirmation message upon successful password retrieval.
2. **Secure File Storage**
    - Users can encrypt and upload files to the cloud.
    - File metadata is stored securely in the blockchain to ensure tamper-proof records.

The system confirms secure storage with a success message. This workflow enhances security by ensuring encrypted password storage, blockchain-based file metadata protection, and a user-

4.REQUIREMENT SPECIFICATION

Hardware and Software Requirements

4.1 Hardware Requirements:

- Processor: Dual-core CPU (Intel i5 or AMD equivalent)
- RAM: 4GB or higher
- Storage: 100GB+ HDD/SSD
- Internet: Stable broadband connection (10 Mbps or higher)
- GPU (Optional): NVIDIA/AMD GPU for cryptographic acceleration.

4.2 Software Requirements:

- Operating System: Windows, Linux (Ubuntu), or macOS
- Cloud Storage Platforms: IPFS, Amazon S3, or Google Cloud Storage
- Programming Languages: Python, JavaScript.
- Database: MongoDB, PostgreSQL, or Firebase
- Security Tools: AES-256 encryption, Post-Quantum Cryptography (PQC)
- Development Tools: Visual Studio Code, PyCharm, Remix IDE
- Version Control: Git, GitHub, or GitLab

5.IMPLEMENTATION

blinker==1.7.0

click==8.1.7

Flask==3.0.0

Flask-Login==0.6.3

Flask-SQLAlchemy==3.1.1

greenlet==3.0.2

itsdangerous==2.1.2

Jinja2==3.1.4

MarkupSafe==2.1.3

SQLAlchemy==2.0.23

typing_extensions==4.8.0

Werkzeug==3.0.3

Centralised server blockchain:

```
from flask import Flask, jsonify, request
import requests
import random
import os
from dotenv import load_dotenv
app = Flask(__name__)
load_dotenv()
# Fetch nodes from .env file and convert to a list
OTHER_SERVERS = os.getenv("OTHER_SERVERS", "").split(",")
# Remove empty entries (if .env is misconfigured)
NODES = [server.strip() for server in OTHER_SERVERS if server.strip()]
@app.route('/add_block', methods=['POST'])
def add_block():
```

```
    node = random.choice(NODES)
    try:
        res = requests.post(f"{node}/add_block", json=request.json)
        return jsonify(res.json()), res.status_code
    except requests.RequestException as e:
        return jsonify({"error": "Node unreachable or error", "details": str(e)}), 503
@app.route('/get_chain', methods=['GET'])
def get_chain():
    chains = []
    unique_hashes = set()

    for node in NODES:
        try:
            res = requests.get(f"{node}/get_chain").json()
            for block in res['chain']:
                if block['hash'] not in unique_hashes and block['index'] != 0:  # Filter Genesis Block
                    unique_hashes.add(block['hash'])
                    chains.append(block)
        except:
            continue

 chains.sort(key=lambda x: x['index'])
    return jsonify({"chain": chains}), 200
@app.route('/delete_block/<int:index>', methods=['DELETE'])
def delete_block(index):
    success = False
    for node in NODES:
        try:
```

```
            res = requests.delete(f"{node}/delete_block/{index}")
            if res.status_code == 200:
                success = True
        except:
            continue
    if success:
        return jsonify({"message": "Block marked as deleted."}), 200
    else:
        return jsonify({"error": "Block not found on any node."}), 404
@app.route('/password-list', methods=['POST'])
def password_list():
    """Returns list of blocks where type is 'password' for a specific user."""
    data = request.json
    user_email = data.get("email")
    user_id = data.get("user_id")

    if not user_email or not user_id:
        return jsonify({"error": "Missing email or user_id"}), 400
  chains = []
    unique_hashes = set()

    for node in NODES:
        try:
            res = requests.get(f"{node}/get_chain").json()
            for block in res['chain']:
                if (block['hash'] not in unique_hashes
                    and block['index'] != 0  # Filter Genesis Block
                    and block['data'].get("type") == "password"
                    and block['data'].get("email") == user_email
```

```
                and block['data'].get("user_id") == user_id):

                unique_hashes.add(block['hash'])
                chains.append(block)
        except:
            continue

    chains.sort(key=lambda x: x['index'])
    return jsonify({"passwords": chains}), 200
@app.route('/filedata-list', methods=['POST'])
def filedata_list():
    """Returns list of blocks where type is 'file' for a specific user."""
    data = request.json
    user_email = data.get("email")
    user_id = data.get("user_id")

    if not user_email or not user_id:
        return jsonify({"error": "Missing email or user_id"}), 400chains = []
    unique_hashes = set()

    for node in NODES:
        try:
            res = requests.get(f"{node}/get_chain").json()
            for block in res['chain']:
                if (block['hash'] not in unique_hashes
                    and block['index'] != 0  # Filter Genesis Block
                    and block['data'].get("type") == "file"
                    and block['data'].get("email") == user_email
                    and block['data'].get("user_id") == user_id):
```

```
                unique_hashes.add(block['hash'])
                chains.append(block)
        except:
            continue

    chains.sort(key=lambda x: x['index'])
    return jsonify({"files": chains}), 200

if __name__ == '__main__':
    app.run(host='0.0.0.0', port=5000, debug=True)
```

Blockchain node:

```
from flask import Flask, jsonify, request
import hashlib
import time
import json
import requests
from pymongo import MongoClient
import sys
from dotenv import load_dotenv
import os
app = Flask(__name__)
PORT = int(sys.argv[1]) if len(sys.argv) > 1 else 5051
load_dotenv()
OTHER_SERVERS = os.getenv("OTHER_SERVERS", "").split(",")
OTHER_SERVERS = [server.strip() for server in OTHER_SERVERS if server.strip()]
# MongoDB setup
client = MongoClient("mongodb://localhost:27017/")
```

```
db = client[f"blockchain_{PORT}"]
blocks_collection = db.blocks
class Block:
    def __init__(self, index, timestamp, data, previous_hash, deleted=False):
        self.index = index
        self.timestamp = timestamp
        self.data = data
        self.previous_hash = previous_hash
        self.deleted = deleted
        self.hash = self.calculate_hash()

    def calculate_hash(self):
        data_to_hash                                                                    =
f"{self.index}{self.timestamp}{json.dumps(self.data)}{self.previous_hash}{self.d
eleted}"
        return hashlib.sha256(data_to_hash.encode()).hexdigest()
class Blockchain:
    def __init__(self)
 if blocks_collection.count_documents({}) == 0:
            genesis = Block(0, time.time(), {"message": "Genesis Block"}, "0")
            self.save_block(genesis)

    def get_all_blocks(self, include_deleted=False):
        query = {} if include_deleted else {"deleted": False}
        blocks = list(blocks_collection.find(query, {"_id": 0}).sort("index", 1))
        return blocks
def add_block(self, data):
        blocks = self.get_all_blocks(include_deleted=True)
        latest_block = blocks[-1]
```

```
new_block = Block(latest_block['index'] + 1, time.time(), data, latest_block['hash'])
        self.save_block(new_block)
        self.broadcast_new_block(new_block)
 return new_block
  def save_block(self, block):
        block_dict = {
            "index": block.index,
            "timestamp": block.timestamp,
            "data": block.data,
            "previous_hash": block.previous_hash,
            "hash": block.hash,
            "deleted": block.deleted
        }
        blocks_collection.insert_one(block_dict)
def is_chain_valid(self):
        blocks = self.get_all_blocks(include_deleted=True)
        for i in range(1, len(blocks)):
            if blocks[i]['previous_hash'] != blocks[i-1]['hash']:
                return False
            recalculated_hash = Block(
                blocks[i]['index']
    blocks[i]['timestamp'],
                blocks[i]['data'],
                blocks[i]['previous_hash'],
                blocks[i]['deleted']
            ).calculate_hash()
            if blocks[i]['hash'] != recalculated_hash:
                return False
        return True
```

```
    def broadcast_new_block(self, block):
        OTHER_SERVERS = [url for url in OTHER_SERVERS if not
url.endswith(str(PORT))]

        for server in OTHER_SERVERS:
            try:
                requests.post(f"{server}/receive_block", json=block.__dict__)
            except:
                continue
blockchain = Blockchain()
@app.route('/receive_block', methods=['POST'])
def receive_block():
    block = request.json
    if block:
        existing_block = blocks_collection.find_one({"hash": block["hash"]})
        if existing_block:
            return jsonify({"message": "Block already exists."}), 200
        blocks_collection.insert_one(block)
        return jsonify({"message": "Block added from broadcast."}), 201
    return jsonify({"error": "Invalid data."}), 400
@app.route('/add_block', methods=['POST'])
def add_block():
    data = request.json.get("data")
    if not data:
    return jsonify({"error": "Data is required"}), 40
new_block = blockchain.add_block(data)
    return jsonify({"message": "Block added", "block": {
        "index": new_block.index,
```

```
        "timestamp": new_block.timestamp,
        "data": new_block.data,
        "previous_hash": new_block.previous_hash,
        "hash": new_block.hash,
        "deleted": new_block.deleted
    }}), 201
@app.route('/get_chain', methods=['GET'])
def get_chain():
    blocks = blockchain.get_all_blocks()
    return jsonify({"chain": blocks}), 200
@app.route('/delete_block/<int:index>', methods=['DELETE'])
def delete_block(index):
    result = blocks_collection.update_one({"index": index}, {"$set": {"deleted":
True}})
    if result.modified_count > 0:
        return jsonify({"message": "Block marked as deleted."}), 200
    return jsonify({"error": "Block not found."}), 404
@app.route('/sync_chain', methods=['GET'])
def sync_chain():
    OTHER_SERVERS = [url for url in OTHER_SERVERS if not
url.endswith(str(PORT))]
longest_chain = []
    for server in OTHER_SERVERS:
        try:
            chain = requests.get(f"{server}/get_chain").json()['chain']
            if len(chain) > len(longest_chain):
                longest_chain = chain
        except:
            continue
```

```
    if longest_chain:
        blocks_collection.delete_many({})
        blocks_collection.insert_many(longest_chain)
        return jsonify({"message": "Blockchain synced."}), 200

    return jsonify({"message": "Already up to date."}), 200

if __name__== '__main__':
    app.run(host='0.0.0.0', port=PORT, debug=True).
```

Text encryption :

```
from quantcrypt.kem import Kyber
from Crypto.Cipher import AES
import base64

class CryptoKyber:
    def __init__(self, public_key_path, private_key_path):
        self.kem = Kyber()

        # Load or generate keys
        try:
            with open(public_key_path, 'rb') as f:
                self.public_key = f.read()
            with open(private_key_path, 'rb') as f:
                self.private_key = f.read()
        except FileNotFoundError:
            # Generate keys if not found
            self.public_key, self.private_key = self.kem.keygen()
            with open(public_key_path, 'wb') as f:
```

```
            f.write(self.public_key)
        with open(private_key_path, 'wb') as f:
            f.write(self.private_key)

    def encrypt_message(self, message, salt):
        # Encapsulate shared secret using the public key
        encrypted_session_key, shared_secret = self.kem.encaps(self.public_key)

        # Add salt to the message
        message_with_salt = salt + message.encode()

        # Encrypt message using AES with the shared secret
        cipher_aes = AES.new(shared_secret[:16], AES.MODE_CBC)
        ciphertext = cipher_aes.encrypt(self.pad_data(message_with_salt))

        # Return encrypted session key, AES IV, and ciphertext
        return base64.b64encode(encrypted_session_key),
base64.b64encode(cipher_aes.iv), base64.b64encode(ciphertext)

    def decrypt_message(self, encrypted_session_key_b64, iv_b64, ciphertext_b64,
salt):
        # Decode base64-encoded inputs
        encrypted_session_key = base64.b64decode(encrypted_session_key_b64)
        iv = base64.b64decode(iv_b64)
        ciphertext = base64.b64decode(ciphertext_b64)

        # Decapsulate shared secret using the private key
        shared_secret = self.kem.decaps(self.private_key, encrypted_session_key)
```

```
        # Decrypt message using AES with the shared secret
        cipher_aes = AES.new(shared_secret[:16], AES.MODE_CBC, iv)
        decrypted_message_with_salt =
self.unpad_data(cipher_aes.decrypt(ciphertext))

        # Validate salt and extract original message
        if decrypted_message_with_salt[:len(salt)] != salt:
            raise ValueError("Salt verification failed.")
        return decrypted_message_with_salt[len(salt):].decode()

    def pad_data(self, data):
        block_size = AES.block_size
        padding = block_size - len(data) % block_size
        return data + bytes([padding] * padding)

    def unpad_data(self, data):
        padding = data[-1]
        return data[:-padding]


def text_encryption(public_key_path, private_key_path, message, salt):
    kyber_instance = CryptoKyber(public_key_path, private_key_path)
    encrypted_key, iv, ciphertext = kyber_instance.encrypt_message(message, salt)
    return encrypted_key, iv, ciphertext


def text_decryption(encrypted_key, iv, ciphertext, salt, public_key_path,
private_key_path):
    kyber_instance = CryptoKyber(public_key_path, private_key_path)
```

```
    decrypted_message = kyber_instance.decrypt_message(encrypted_key, iv, ciphertext, salt)
    return decrypted_message
```

file encryption:

```
from quantcrypt.kem import Kyber
from Crypto.Cipher import AES
import base64
class FileCryptoKyber:
    def __init__(self, public_key_path, private_key_path):
        self.kem = Kyber()

        # Load or generate keys
        try:
            with open(public_key_path, 'rb') as f:
                self.public_key = f.read()
            with open(private_key_path, 'rb') as f:
                self.private_key = f.read()
        except FileNotFoundError:
            # Generate keys if not found
            self.public_key, self.private_key = self.kem.keygen()
            with open(public_key_path, 'wb') as f:
                f.write(self.public_key)
            with open(private_key_path, 'wb') as f:
                f.write(self.private_key)

    def encrypt_file(self, file_data, salt):
        # Encapsulate shared secret using the public key
        encrypted_session_key, shared_secret = self.kem.encaps(self.public_key)
```

```
    # Add salt to the data
    data_with_salt = salt + file_data

    # Encrypt data using AES with the shared secret
    cipher_aes = AES.new(shared_secret[:16], AES.MODE_CBC)
    padded_data = self.pad_data(data_with_salt)
    ciphertext = cipher_aes.encrypt(padded_data)

    return encrypted_session_key, cipher_aes.iv, ciphertext

def decrypt_file(self, encrypted_session_key, iv, ciphertext, salt):
    # Decapsulate shared secret using the private key
    shared_secret = self.kem.decaps(self.private_key, encrypted_session_key)

    # Decrypt data using AES
    cipher_aes = AES.new(shared_secret[:16], AES.MODE_CBC, iv)
    decrypted_data_with_salt = cipher_aes.decrypt(ciphertext)

    # Validate and remove salt
    if decrypted_data_with_salt[:len(salt)] != salt:
        raise ValueError("Salt verification failed.")
    return self.unpad_data(decrypted_data_with_salt[len(salt):])

@staticmethod
def pad_data(data):
    block_size = AES.block_size
    padding = block_size - (len(data) % block_size)
    return data + bytes([padding] * padding)
```

```
    @staticmethod
    def unpad_data(data):
        padding = data[-1]
        return data[:-padding]
```

Common data encryption:

```
import os
import base64
from Crypto.Cipher import AES
from dotenv import dotenv_values, set_key

class AESCipher:
    def   _init_(self,   env_path=".env"):
        self.env_path = env_path
        self.env_vars  =  dotenv_values(env_path)
        key_encoded = self.env_vars.get("KEY")
        iv_encoded = self.env_vars.get("IV")

        if key_encoded is None or iv_encoded is None:
            # Generate new key and IV if they are missing
            self.key_bytes = os.urandom(32)
            self.iv_bytes = os.urandom(16)
            set_key(self.env_path, "KEY", self.key_bytes.hex())
            set_key(self.env_path, "IV", self.iv_bytes.hex())
        else:

            self.key_bytes = bytes.fromhex(key_encoded)
            self.iv_bytes = bytes.fromhex(iv_encoded)
    def pad_data(self, data):
        # PKCS7 Padding
```

```
        pad_length = AES.block_size - (len(data) % AES.block_size)
        return data + bytes([pad_length] * pad_length)
    def encrypt_data(self, data):
        cipher = AES.new(self.key_bytes, AES.MODE_CBC, iv=self.iv_bytes)
        padded_data = self.pad_data(data.encode())
        ciphertext = cipher.encrypt(padded_data)
        return ciphertext
# Example usage
#aes_cipher = AESCipher()

# data = "12345678901234567890123ert67890123456789012345678901234567890"
# encrypted_data = aes_cipher.encrypt_data(data)
# print("Encrypted data:", encrypted_data)
# print(len(encrypted_data))

# decrypted_data = aes_cipher.decrypt_data(encrypted_data)
# print("Decrypted data:", decrypted_data)
```

MAIN ROUTE CODE:

```
from flask import Blueprint, render_template, request, flash, redirect, url_for,jsonify,abort,session
from . import db
from .models import User,Text,File,DeleteAccount,Feedback
from flask_login import login_required,current_user
from .utils.sysinfo import *
from .utils.forms import *
from .utils.encryption import dict_to_string, string_to_dict
from .utils.file_utils import generate_filename
from .utils.email_utils import send_verification_email
from flask  import current_app as app
```

```
from .utils.Encryption.TextEncryption import text_encryption,text_decryption
from .utils.Encryption.dataencryption import AESCipher

# from .utils.config import Config
import os
from werkzeug.utils import secure_filename
import threading
import base64
from .utils.Encryption.FileEncryption import *
import traceback
from .utils.Converter import Converter
aes_cipher = AESCipher()
from base64 import b64decode, b64encode

view = Blueprint('view', __name__)@view.route('/',methods=['POST','GET'])
@login_required
def home():
    if current_user.is_verified != True:
        flash("Verify Your Email")
        return redirect(url_for('auth.logout'))
    else:
            fileform=FileForm()
            user = User.query.get_or_404(current_user.id);
            if user.used_storage == user.limited_storage :
                flash("Your storage is full")

                return redirect(url_for('view.profile'))
            form = PasswordForm()
```

```
    return render_template('home.html',form=form,fileform=fileform)
@view.route('/admin',methods=['POST','GET'])
@login_required
def admin():

    if current_user.role == 'admin':
        system_info_printer = SystemInfoPrinter()
        storage_info= system_info_printer.print_storage_info()
        system_info =system_info_printer.print_system_info()
        user = User.query.order_by(User.date)
        feedback = Feedback.query.order_by(Feedback.date)



    else:
        flash("You Don't have a Access")
        return redirect(url_for('view.home'))



    return render_template
('admin.html',storage_info=storage_info,system_info=system_info,user=user,feedb
ack=feedback)

@view.route('/password', methods=['POST'])
@login_required
def store_pass():
    form = PasswordForm()
    if request.method == 'POST' and form.validate_on_submit():
        url = form.url.data
        name = form.name.data
```

```
        username = form.username.data
        password = form.password.data
        keypath = app.config['KEY_FOLDER']
        data = {'url': url, 'name': name, 'username': username, 'password': password,
'keypath': keypath}

        string = dict_to_string(data)

        public_key_path = os.path.join(keypath, 'public_key',
aes_cipher.decrypt_data(current_user.path), generate_filename('der'))
        encrypted_public = aes_cipher.encrypt_data(public_key_path)  # Assuming
public_key_path is bytes

        private_key_path = os.path.join(keypath, 'private_key',
aes_cipher.decrypt_data(current_user.path), generate_filename('der'))
        encrypted_private = aes_cipher.encrypt_data(private_key_path)  # Assuming
private_key_path is bytes

        encrypted_session_key, iv, ciphertext = text_encryption(public_key_path,
private_key_path, string, salt=session.get('salt'))

        stype = aes_cipher.encrypt_data("password")

        newtext = Text(user_id=current_user.id,
encrypted_Key=encrypted_session_key, nonce=iv, ciphertext=ciphertext,
private_key_path=encrypted_private, public_key_path=encrypted_public,
store_type=stype)
        db.session.add(newtext)
        db.session.commit()
```

```
    return redirect(url_for('view.home'))

@view.route('/showpass', methods=['POST', 'GET'])
@login_required
def showpass():
    form = EditPasswordForm()
    if current_user.is_authenticated:
        passwords = Text.query.filter_by(user_id=current_user.id)
        data = []
        # decryption_ = CryptoKyber()
        for password in passwords:
            decrypted_public_key_path =
aes_cipher.decrypt_data(password.public_key_path)  # Assuming it's bytes
            decrypted_private_key_path =
aes_cipher.decrypt_data(password.private_key_path)  # Assuming it's bytes



decrypted_message=text_decryption(encrypted_key=password.encrypted_Key,
iv=password.nonce,      ciphertext=password.ciphertext,      salt=session.get('salt'),
public_key_path=decrypted_public_key_path,
private_key_path=decrypted_private_key_path)

            data.append({
                "id": password.id,
                "data": string_to_dict(decrypted_message),
                "store_type": aes_cipher.decrypt_data(password.store_type)
            })
```

```
        return render_template('passwords.html', data=data, form=form)
    else:
        return redirect(url_for('view.home'))



# def ensure_keys(public_key_path, private_key_path):
#     if not os.path.exists(public_key_path) or not os.path.exists(private_key_path):
#         kyber = FileCryptoKyber(public_key_path, private_key_path)
#         kyber.generate_keys()

@view.route('/uploadfile', methods=['POST'])
@login_required
def fileupload():
    form = FileForm()
    if form.validate_on_submit():
        file = form.file.data
        filename = secure_filename(file.filename)
        filemimetype = file.mimetype

        # File paths and key paths
        keypath = app.config['KEY_FOLDER']
        user_folder = aes_cipher.decrypt_data(current_user.path)
        public_key_path = os.path.join(keypath, 'public_key', user_folder, generate_filename('der'))
        private_key_path = os.path.join(keypath, 'private_key', user_folder, generate_filename('der'))
        filepath = os.path.join(app.config['UPLOAD_FOLDER'], user_folder, generate_filename('file') + filename)
```

```
        # Save file temporarily
        try:
            file.save(filepath)
        except Exception as e:
            flash(f"File upload failed: {e}")
            return redirect(url_for('view.fileupload'))

        # Encrypt file
        try:
            with open(filepath, 'rb') as f:
                file_data = f.read()

            salt = current_user.salt
            kyber_instance = FileCryptoKyber(public_key_path, private_key_path)
            encrypted_key, iv, ciphertext = kyber_instance.encrypt_file(file_data, salt)

            # Save encrypted data to a new file
            encrypted_filepath = filepath
            with open(encrypted_filepath, 'wb') as f:
                f.write(ciphertext)

            ■ Fix: Convert all binary fields to bytes before storing
            addnew = File(
                filename=b64encode(filename.encode()),  # Convert to bytes
                filepath=b64encode(encrypted_filepath.encode()),  # Convert to bytes
                private_key_path=b64encode(private_key_path.encode()),     # Convert to
bytes
```

```
            public_key_path=b64encode(public_key_path.encode()),     # Convert to
bytes
            user_id=current_user.id,
            mimetype=b64encode(filemimetype.encode()), # Convert to bytes
            iv=iv, # Already bytes
            encrypted_key=encrypted_key # Already bytes
        )

        db.session.add(addnew)
        db.session.commit()

    except Exception as e:
        print(traceback.format_exc())
        flash(f"Encryption failed: {e}")
        return redirect(url_for('view.fileupload'))

  return redirect(url_for('view.home'))



@view.route('/showfile')
@login_required
def decrypt_file():
  user_files = current_user.files
  file_data_list = []

  # Get the absolute path to the static folder
  static_folder = os.path.abspath(app.config['STATIC_FOLDER'])
  decrypt_folder = os.path.join(static_folder, 'Decrypt')
```

```
    for db_file in user_files:
        try:
            # Decode file paths
            file_path = b64decode(db_file.filepath).decode()
            private_key_path = b64decode(db_file.private_key_path).decode()
            public_key_path = b64decode(db_file.public_key_path).decode()
            encrypted_key = db_file.encrypted_key
            iv = db_file.iv
            salt = current_user.salt

            # Read encrypted file
            with open(file_path, 'rb') as f:
                ciphertext = f.read()

            # Decrypt the file
            kyber_instance = FileCryptoKyber(public_key_path, private_key_path)
            decrypted_data = kyber_instance.decrypt_file(encrypted_key, iv, ciphertext,
salt)

            # Create user-specific decrypt folder
            user_folder = aes_cipher.decrypt_data(current_user.path)
            user_decrypt_path = os.path.join(decrypt_folder, user_folder)
            os.makedirs(user_decrypt_path, exist_ok=True)

            # Create decrypted file path
            decrypted_filename = secure_filename(os.path.basename(file_path))
            decrypted_filepath = os.path.join(user_decrypt_path, decrypted_filename)

            # Save decrypted file
```

```
            with open(decrypted_filepath, 'wb') as f:
                f.write(decrypted_data)

            # Update database status
            db_file.status = "Decrypted"
            db.session.commit()
            filee=b64decode(db_file.filename).decode()
            print("filee ",filee)
            # Generate URL - create path relative to static folder
            relative_path = os.path.relpath(decrypted_filepath, static_folder)
            relative_path = relative_path.replace('\\', '/')     # Convert Windows paths to
URL format

            # Store file info for display
            file_data_list.append({
                'file_path': url_for('static', filename=relative_path),
                "filename":filee,
                'mimetype': b64decode(db_file.mimetype).decode()
            })

        except Exception as e:
            print(traceback.format_exc())
            flash(f"Decryption failed: {str(e)}", 'error')
            continue

    return render_template('decrypted_file.html', file_data_list=file_data_list)


@view.route('/profile', methods=['POST'])
```

```
@login_required
def save_profile():
    if request.method == 'POST':
        username = request.form.get('username')
        email = request.form.get('email')
        print('username:', username)
        print('Email: ', email)

        user_id = current_user.id
        user = User.query.get_or_404(user_id)

        # Encrypt data, encoding to bytes if necessary
        user.username = aes_cipher.encrypt_data(username)
        user.email = aes_cipher.encrypt_data(email)
        user.is_verified=False
        send_verification_email(user)
        flash('Verify Your Email')



        db.session.commit()

    return redirect(url_for('view.profile'))




@view.route('/profile', methods=['GET'])
@login_required
def profile():
```

```
    form=ProfileForm()
    convert=Converter()
    user_id = current_user.id
    user = User.query.get_or_404(user_id)
    used = user.used_storage
    print('used', used)
    limit = user.limited_storage
    print('limit', limit)
    percentage=Converter.calculate_percentage(used,limit)
    print("percentage",percentage)
    users = {
        'username': aes_cipher.decrypt_data(user.username),
        'email': aes_cipher.decrypt_data(user.email),
        'used_storage': convert.convert_to_GB(used),
        'limited_storage': convert.convert_to_GB(limit)
    }

    return render_template('profile.html', users=users,form=form)


@view.route('/edit-password', methods=['POST'])
@login_required
def edit_password():
    print("Method :",request.method)
    if request.method == 'POST':
        id= request.form.get('id')
        url=request.form.get('url')
        username = request.form.get('username')
        password=request.form.get('password')
```

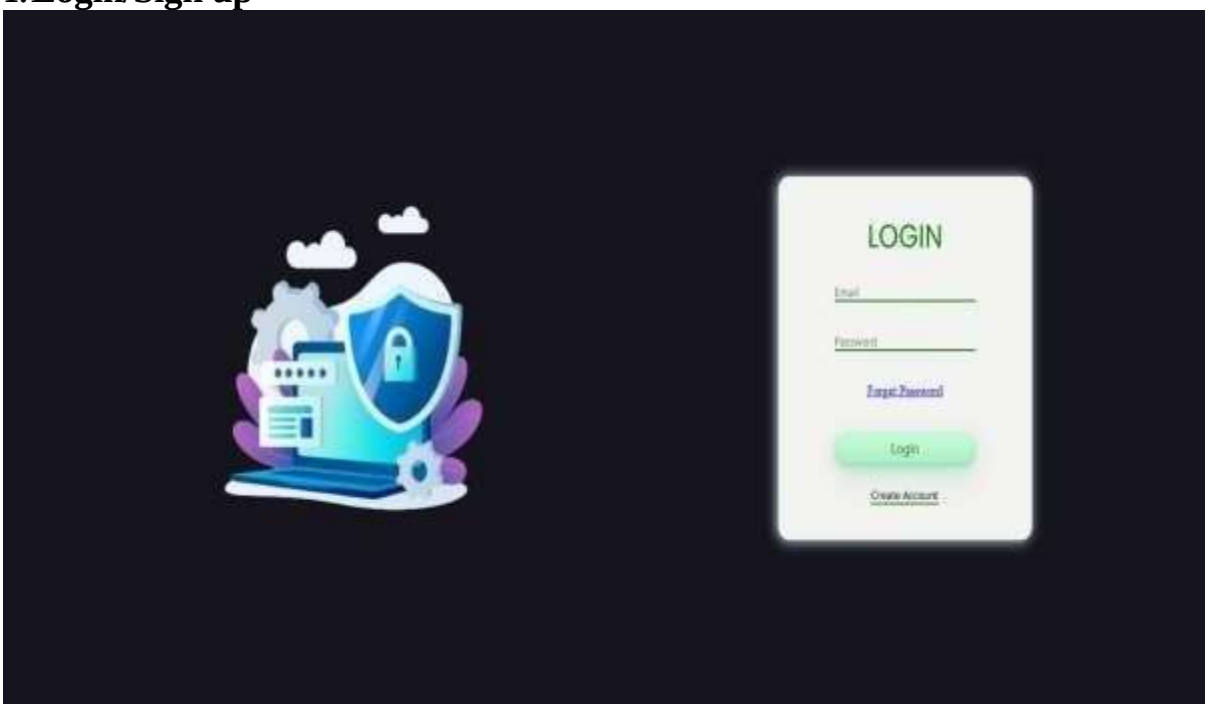
```
        name=request.form.get('name')
        print("ID :",id,"\n url :",url,"\n username :",username," \n
password:",password)
        text = Text.query.get_or_404(id)
        # print("\n\n\n\n\t",text.user_id,"\n\n\n\n\t")
        if text and text.user_id == current_user.id:
            # print("\n\n \t",True ,"\n \n\t")
            keypath=app.config['KEY_FOLDER']

data={'url':url,'name':name,'username':username,'password':password,'keypath':key
path}
            string=dict_to_string(data)

public_key_path=os.path.join(keypath,'public_key',aes_cipher.decrypt_data(curren
t_user.path),generate_filename('der'))
            print('public_key_path',public_key_path)
            encrypted_public=aes_cipher.encrypt_data(public_key_path)

private_key_path=os.path.join(keypath,'private_key',aes_cipher.decrypt_data(curre
nt_user.path),generate_filename('der'))
            print('private_key_path',private_key_path)
            encrypted_private=aes_cipher.encrypt_data(private_key_path)
            encrypted_session_key, iv, ciphertext = text_encryption(public_key_path,
private_key_path, string)
            stype=aes_cipher.encrypt_data("password")

            path=aes_cipher.decrypt_data(text.private_key_path)
            if os.path.exists(path):
                os.remove(path)
```

```
            else:
                print(f"File not found: {path}")
            path=aes_cipher.decrypt_data(text.public_key_path)
            if os.path.exists(path):
                os.remove(path)

            text.user_id=current_user.id
            text.encrypted_Key=encrypted_session_key
            text.nonce=iv
            text.ciphertext=ciphertext
            text.private_key_path=encrypted_private
            text.public_key_path=encrypted_public
            text.store_type=stype
            db.session.commit()
    return redirect(url_for('view.showpass'))


@view.route('/delete-me', methods=['POST', 'GET'])
@login_required  # Ensure the user is logged in
def deleteaccount():
    try:
        # Create a new entry in the DeleteAccount table with decrypted email
        addnew = DeleteAccount(user_id=current_user.id,
email=aes_cipher.decrypt_data(current_user.email))
        db.session.add(addnew)

        # Set the user's is_verified attribute to False
        current_user.is_verified = False
        print(current_user.is_verified)
```

```
        # Commit the transaction to the database
        db.session.commit()

     # Flash a success message
        flash('Your account deletion request has been submitted.', 'success')

    except Exception as e:
        # Rollback the session in case of an error
        db.session.rollback()
        flash(f'An error occurred: {str(e)}', 'danger')

    # Redirect to the home page
    return redirect(url_for('view.home'))

@view.route('/about',methods=['POST','GET'])
def about():
    form=FeedBack()
    if form.validate_on_submit() and request.method == 'POST':
        name = form.name.data
        email = form.email.data
        text=form.text.data
        print("Name :"+name)
        print("Email :"+ email)
        print("Text :"+ text)
   feedback=Feedback(name=name,email=email,text=text)
        db.session.add(feedback)        db.session.commit()
    return render_template("About.html",form=form)
```

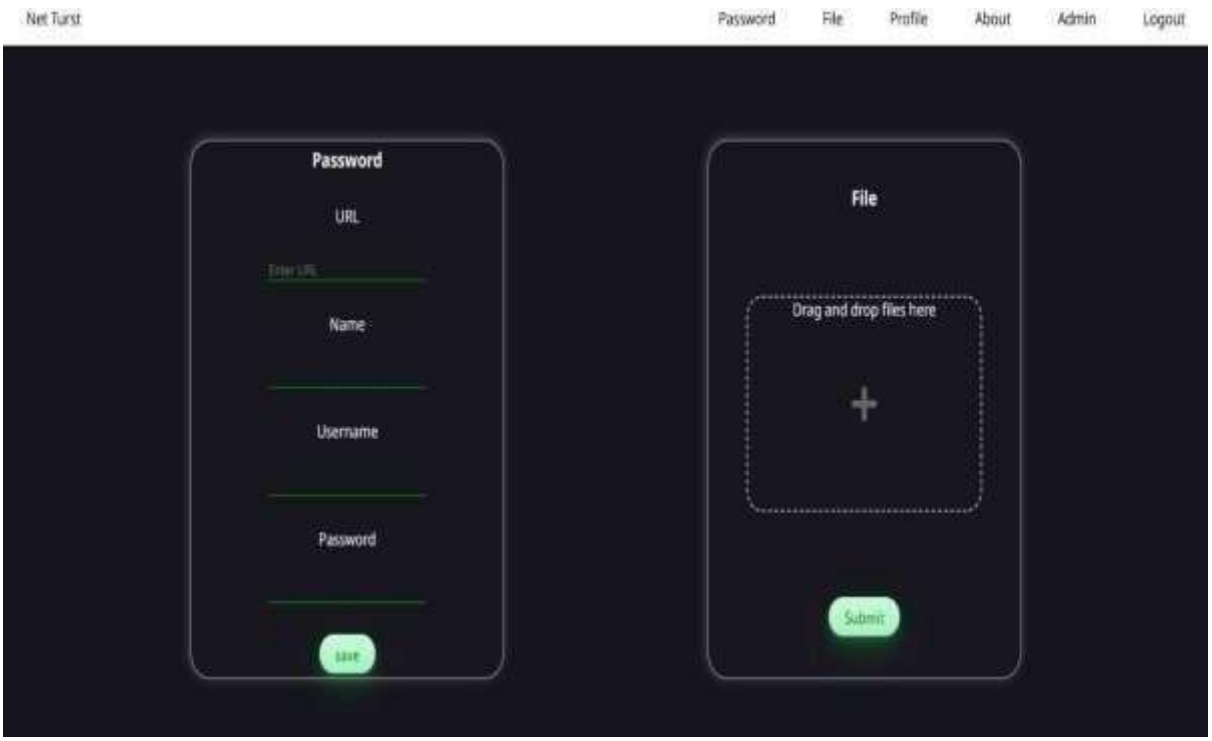
5.1 SNAPSHOTS :

1. Login/Sign up



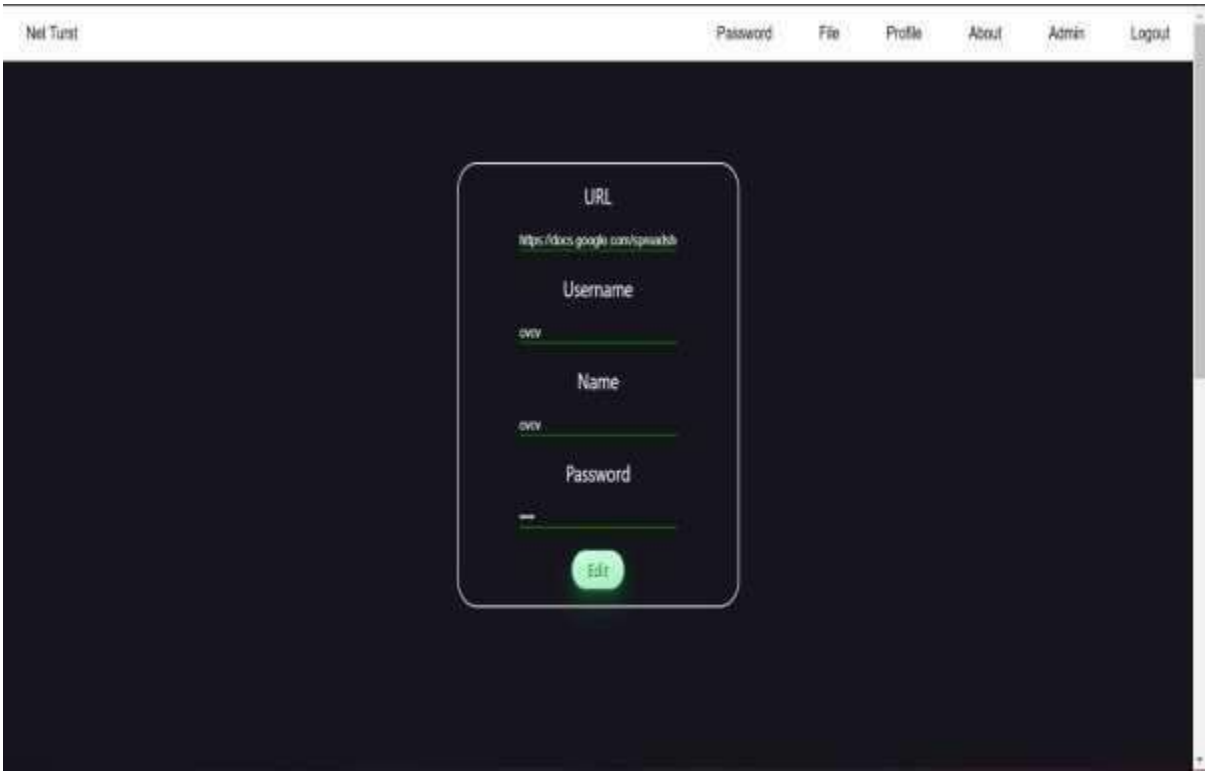
5.1.1 Screen Shot for Login/Sign up

2. Password upload/File upload



5.1.2 Screen Shot for Password upload/File upload

3. Password View

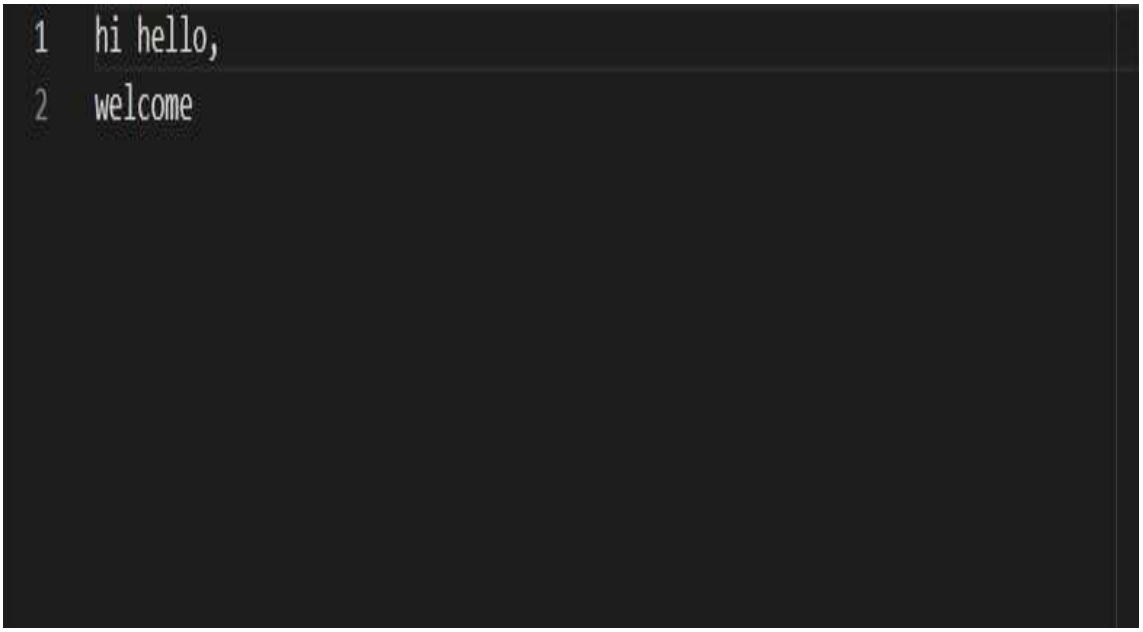


5.1.3 Screen Shot for Password View

4. File View

5.1.4 Screen Shot for File View

5. Before Encrypting the Data



5.1.5 Screen Shot Displaying Data Before Encryption

6. After Encryption the File

5.1.6 Screen Shot Displaying Data After Encryption

6.1.1 Black Box Testing

Black box testing also called behavioral testing focuses on the functional requirements of the software. That is black box testing enables the software engineer to derive sets of input conditions that will fully exercise all functional requirements for a program. Black box testing attempts to find errors in the following categories.

- ✓ Incorrect or missing functions.
- ✓ Errors in data structures.
- ✓ External data base access.
- ✓ Behaviour or performance errors.
- ✓ Initialization and termination errors.

In this project we conduct a thorough Black Box testing to ensure that the output is obtained for all the input conditions.

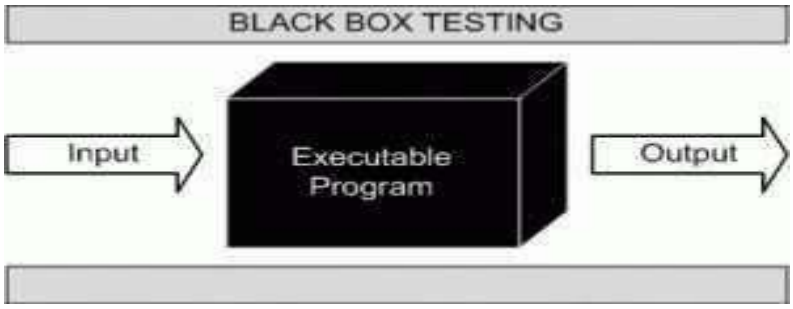


Fig 6.1 Black –box testing outline

6.1.1 White Box Testing

White box testing, sometimes called glass box testing is a test case design method that uses the control structure of the procedural design to derive test cases. Using white box testing methods, the software engineer can derive test cases that guarantee that all independent paths within a module have been exercised at least once.Exercise all logical decisions on their true and false sides. Execute all loops at their boundaries

and within their operational bounds Exercise internal data structures to ensure their validity. White-box test design techniques include:

- ✓ Control flow testing
- ✓ Data flow testing
- ✓ Branch testing
- ✓ Path testing

While white-box testing can be applied at the unit, integration and system levels of the software testing process, it is usually done at the unit level. It can test paths within a unit, paths between units during

6.1.2 Unit Testing

The most 'micro' scale of testing to test particular functions or code modules. Typically, it is done by the programmer and not by tester, as it requires detailed knowledge of the internal program design and code. Unit testing is a method by which individual units of source code are tested to determine if they are fit for use. A unit is the smallest testable part of an application. In procedural programming a unit could be an entire module but is more commonly an individual function or procedure. In object-oriented programming a unit is often an entire interface, such as a class, but could be an individual method. Unit tests are created by programmers or occasionally by white box testers during the development process. Ideally, each test case is independent from the others: substitutes like method stubs, mock objects, fakes and test harnesses can be used to assist testing a module in isolation. Unit tests are typically written and run by software developers to ensure that code meets its design and behaves as intended. Its implementation can vary from being very manual (pencil and paper) to being formalized as part of build automation. Depending upon established development practices and unit test coverage, up-to-the-second accuracy can be maintained.

Ideally, each test case is independent from the others: substitutes like method stubs, mock objects, fakes, and test harnesses can be used to assist testing a module in isolation.

The goal of unit testing is to isolate each part of the program and show that the individual parts are correct. A unit test provides a strict, written contract that the piece of code must satisfy. As a result, it affords several benefits. Unit tests find problems early in the development cycle.

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that the individual parts are correct. A unit test provides a strict, written contract that the piece of code must satisfy. As a result, it affords several benefits. Unit tests find problems early in the development cycle.

Writing unit tests

i. Unit test should be conveniently located

a. For small projects you can imbed the unit test for a module in the module itself.

b. For larger projects you should keep the tests in the package directory or a /test subdirectory of the package.

ii. By making the code accessible to developers you provide them with:

a. Examples of how to use all the functionality of each module

b. A means to build regression tests to validate any future changes to the code

c. In Java, you can use the main routine to run each unit tests.

d. A test harness can handle common operations such a Logging status, Analyzing output for expected results, Selecting and running the tests. Harnesses can be GUI driven, Written in the same language as the rest of the project, May be implemented as a combination of make files and scripts. A test harness should include the following capabilities:

e. A standard way to specify setup and cleanup.

f. A method for selecting individual tests or all available tests.

g. A means of analyzing output for expected (or unexpected) results.

h. A standardized form of failure reporting.

In this Project we conduct unit testing in order to prove that the individual parts of the program works correctly. The procedure level testing is made first. By giving improper inputs, the errors occurred are noted and eliminated. Then the web form level testing is made. For example storage of data to the table in the correct manner. In the company as well as seeker registration form, the zero length

username and password are given and checked. Also the duplicate username is given and checked. In the job and question entry, the button will send data to the server only if the client side validations are made. The dates are entered in wrong manner and checked. Wrong email-id and web site URL (Universal Resource Locator) is given and checked.

Tasks

- Unit Test Plan
  - Prepare
  - Review
  - Rework
  - Baseline
- Unit Test
  - Perform

6.1.3 Integration Testing

Integration testing (sometimes called Integration and Testing, abbreviated "I&T") is the phase in software testing in which individual software modules are combined and tested as a group. It occurs after unit testing and before validation testing. Integration testing takes as its input modules that have been unit tested, groups them in larger aggregates, applies tests defined in an integration test plan to those aggregates, and delivers as its output the integrated system ready for system testing.The purpose of integration testing is to verify functional, performance, and reliability requirements placed on major design items. These "design items", i.e. assemblages (or groups of units), are exercised through their interfaces using Black box testing, success and error cases being simulated via appropriate parameter and data inputs. Simulated usage of shared data areas and inter-process communication is tested and individual subsystems are exercised through their input interface. Test cases are constructed to test that all components within assemblages interact correctly, for example across procedure calls or process activations, and this is done

after testing individual modules, i.e. unit testing. The overall idea is a "building block" approach, in
which verified assemblages are added to a verified base which is then used to support the integration testing of further assemblages.

Steps in Integration Testing

i. Based on integration strategy, select a component to be tested. Unit test all the classes in the component.

ii. Put selected component together; do any preliminary fix-up necessary to make the integration testing operational (drivers & stubs).

iii. Do functional testing: Define test cases that exercises all use cases with the selected component.

iv. Do structural testing: Define test cases that exercise selected component.

v. Execute performance tests.

vi. Keep records of test cases and testing activities.

vii. Repeat steps 1-6 until full system is tested.

You can do integration testing in a variety of ways but the following are three common strategies this method we would be very clear of all the bugs that have occurred.

6.1.4 System Testing

Testing the behaviour of the whole software/system as defined in software requirements specification (SRS) is known as system testing, its main focus is to verify that the customer requirements are fulfilled. System testing is done after integration testing is complete. System testing should test functional and non functional requirements of the software. As a rule, system testing takes, as its input, all of the "integrated" software components that have successfully passed integration testing and also the software system itself integrated with any applicable hardware system(s). The purpose of integration testing is to detect any inconsistencies between the software units that are integrated together (called assemblages) or between any of the assemblages and the hardware. System testing is a more limited type of

testing; it seeks to detect defects both within the "inter-assemblages" and also within the system as a whole. Usually a dedicated testing team is responsible for doing ‘System Testing’.

In system testing the software test professional aims to detect defects or bugs both within the interfaces and also within the software as a whole. However, during integration testing of the application or software, the software test professional aims to detect the bugs / defects between the individual units that are integrated together. During system testing, the focus is on the software design, behavior and even the believed expectations of the customer. So, we can also refer the system testing phase of software testing as investigatory testing phase of the software development life cycle.

- First level of software testing where the software / application is tested as a whole.
- It is done to verify and validate the technical, business, functional and non-functional requirements of the software. It also includes the verification & validation of software application architecture.
- System testing is done on staging environment that closely resembles the production environment where the final software will be deployed.

Steps in System Testing

1) Creation of System Test Plan
2) Creation of system test cases
3) Selection / creation of test data for system testing
4) Software Test Automation of execution of automated test cases (if required)
5) Execution of test cases
6) Bug fixing and regression testing
7) Repeat the software test cycle (if required on multiple environments) . In the proposed system testing is done. It is performed to ensure that software function appear to be working according to the specifications and that the performance requirement of the system. After testing all the modules, the modules are integrated

and testing of the final system is done with the test data, specially designed to show that the system will operate successfully in all its aspects conditions. Thus the system testing is a confirmation that all is correct and an opportunity to show the user that the system

6.1.5 Aceptance Testing

The final step involves Acceptance Testing, which determines whether the software functions as expected by the user. This phase ensures that the system meets business requirements and performs as intended in real-world scenarios. The end-user, rather than the system developer, conducts this test. Most software developers follow a process called Alpha and Beta testing to uncover potential issues before the final release.

- **Alpha Testing**: Conducted in a controlled environment by internal testers or developers to identify bugs and ensure core functionality.
- **Beta Testing:** Performed by real users in a live environment to validate usability, performance, and reliability be fore deployment

6.1 Test Report:

S.No	Test Case ID	Test Case Description	Module Name	Condition	Expected O/P	Obtained O/P	Status
1	BCST-001	Verify file upload and encryption	Storage	File uploaded successfully	Encrypted file stored on blockchain	Encrypted file stored on blockchain	Pass
2	BCST-002	Validate file retrieval and decryption	Storage	File retrieved successfully	Decrypted file matches original	Decrypted file matches original	Pass
3	BCST-003	Check user authentication mechanism	Security	Valid user authentication	Access granted	Access granted	Pass
4	BCST-004	Verify unauthorized access restriction	Security	Invalid user attempt	Access denied	Access denied	Pass
5	BCST-005	Test data integrity verification	Blockchain	Verify file hash	Hash matches original	Hash matches original	Pass
6	BCST-006	Ensure load balancer distributes traffic	Load Balancer	Balanced traffic distribution	Requests distributed evenly	Requests distributed evenly	Pass
7	BCST-007	Assess post-quantum cryptographic security	Security	Quantum-resistant encryption applied	Encrypted with PQC algorithm	Encrypted with PQC algorithm	Pass
8	BCST-008	Test AES encryption effectiveness	Security	File encryption with AES	AES-encrypted file stored	AES-encrypted file stored	Pass
9	BCST-009	Check blockchain transaction logging	Blockchain	Transaction recorded successfully	Blockchain ledger updated	Blockchain ledger updated	Pass
10	BCST-010	Evaluate system performance under high load	Performance	System maintains stability	No crashes, stable response time	No crashes, stable response time	Pass

7.CONCLUSION

Blockchain-based cloud storage integrated with Post-Quantum Cryptography (PQC) and AES provides a highly secure, decentralized, and resilient data storage solution. Traditional cloud storage systems face risks such as centralized failures, data breaches, and evolving cyber threats, especially with the advent of quantum computing. By leveraging blockchain technology, data integrity and transparency are ensured, while PQC enhances encryption security to withstand future quantum attacks. The use of AES encryption adds an additional layer of protection, ensuring efficient and secure data transmission.

This project successfully demonstrates how the integration of blockchain, PQC, and AES can create a next-generation cloud storage system that is quantum-resistant and tamper-proof. However, challenges related to scalability, computational efficiency, and energy consumption remain areas for improvement. With further advancements in cryptographic techniques, storage optimization, and AI-driven security, blockchain-based cloud storage will continue to evolve, offering a highly secure and future-proof solution for data protection in the digital era.

Future Enhancements:

In the future, blockchain-based cloud storage can be enhanced by optimizing Post-Quantum Cryptography (PQC) algorithms to improve efficiency while maintaining strong security. Hybrid encryption techniques combining PQC and AES can offer a balanced approach to safeguarding data against quantum threats while reducing computational overhead.

Another key enhancement is scalability, as blockchain networks often face latency and high transaction costs. Implementing Layer-2 scaling solutions, such as sidechains and sharding, can improve transaction speed and reduce congestion, making the system more efficient for large-scale storage applications.

Decentralized storage improvements can also enhance performance by integrating advanced networks like Filecoin and Storj while using compression and

deduplication techniques to optimize storage space. AI-driven security mechanisms can further strengthen the system by detecting anomalies, preventing unauthorized access, and automating threat detection in real-time.

Lastly, energy-efficient blockchain consensus mechanisms, such as Proof-of-Stake (PoS) or Proof-of-Space (PoSpace), can be adopted to reduce computational power consumption. These improvements will make blockchain cloud storage more secure, scalable, and sustainable, ensuring a future-proof solution for data security and privacy.

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