SECURE FILE STORAGE USING HYBRID CRYPTOGRAPHY

A PROJECT REPORT

Submitted by

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In

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Under the esteemed guidance of

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SANKETIKA VIDYA PARISHAD ENGINEERING COLLEGE

NAAC ACCREDITED – AICTE APPROVED

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BONAFIDE CERTIFICATE

This is to certify that the work entitled "**SECURE FILE STORAGE USING HYBRID CRYPTOGRAPHY**" is a bonafide work done by **G. SRAVANI VAISHALI(321132910021), T. ASHISH KUMAR (321132910005), P.JYOTHIKA(321132910044), CH.SURYA SAGAR(321132910060)**as a part of IV/IV B. Tech 2nd Semester of Computer Science and Engineering during the year 2021-2025.

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External Examine

DECLARATION

We hereby declare that the work entitled **"SECURE FILE STORAGE USING HYBRID CRYPTOGRAPHY"** is an original work done by us under the guidance of **K.T. KRISHNA KUMAR,** Associate Professor, and submitted to the Department of Computer Science and Engineering, **SANKETIKA VIDYA PARISHAD ENGINEERING COLLEGE,** for the partial fulfilment of the requirement for the award of Bachelor of Technology in Computer Science and Engineering.

We also declare that this work is a result of our own effort and that it has not been submitted to any other university for the award of any Degree.

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LIST OF ABBREVATIONS

ACRONYM	ABBREVATIONS
AES	ADVANCED ENCRYPTION STANDARD
RSA	RIVEST-SHAMIR-ADLEMAN
Cha Cha20	STREAM CIPHER ALGORITHM
AES - GCM	ADVANCED ENCRYPTION STANDARD - GALOIS/COUNTER MODE
AES -CCM	ADVANCED ENCRYPTION STANDARD - COUNTER WITH CBC-MAC
HMAC	HASH-BASED MESSAGE AUTHENTICATION CODE
ECC	ELLIPTIC CURVE CRYPTOGRAPHY
HTTPS	HYPERTEXT TRANSFER PROTOCOL SECURE
API	APPLICATION PROGRAMMING INTERFACE
HTML	HYPERTEXT MARKUP LANGUAGE
CSS	CASCADING STYLE SHEETS

ABSTRACT

Data security is a critical concern in modern digital systems, particularly for cloud storage solutions where unauthorized access and data breaches are constant threats. This project, Secure File Storage Using Hybrid Cryptography, presents a comprehensive encryption framework to enhance file security by ensuring confidentiality, integrity, and authenticity. By utilizing a combination of symmetric and asymmetric encryption algorithms such as AES, RSA, ChaCha20-Poly1305, AES-GCM, and AES-CCM, the system strengthens data protection while optimizing computational efficiency.

The system employs file chunking to facilitate seamless encryption and decryption, minimizing processing time while enhancing security. Additionally, secure key management techniques are implemented to prevent unauthorized key access, ensuring that only legitimate users can retrieve stored files. A web-based interface allows for easy interaction, making secure file storage accessible even to non-technical users.

Performance evaluations indicate that the system maintains high encryption and decryption speeds without compromising security. Its adaptability allows it to be integrated into various environments, including cloud storage services, enterprise data security infrastructures, and government systems requiring advanced encryption mechanisms. With its combination of efficiency, security, and usability, this project stands as a robust solution for safeguarding digital information against cyber threats in an increasingly interconnected world.

CHAPTER 1
INTRODUCTION

1.1 OBJECTIVE OF THE PROJECT

The objective of this project is to develop a secure file storage system utilizing hybrid cryptographic techniques to enhance data confidentiality and integrity. The rise of cloud computing and frequent data breaches necessitates stronger security measures. Existing systems typically use single-layer encryption, which is insufficient against modern cyber threats. This project integrates multiple encryption technique like AES, RSA, and ChaCha20-Poly1305 to strengthen security.

To ensure unauthorized users cannot access files, the system splits files into chunks and encrypts each piece using different cryptographic methods. This makes it computationally infeasible for attackers to decrypt the entire file, even if part of the encrypted data is exposed. Secure key management techniques are implemented to prevent key leaks and ensure only authorized users can access encryption keys. The system is designed to be secure, efficient, and user-friendly, balancing security and usability while addressing vulnerabilities in cloud storage.

1.2 MOTIVATION

The rise in the number of cyber-attacks, data breaches, and unauthorized access cases has created an urgent need for secure data storage systems. Although conventional encryption technologies are useful, they cannot provide sufficient protection against contemporary attacks. Since both businesses and individuals are relying more and more on cloud storage, there is an exponentially higher chance of sensitive data being hacked. The project is centered on the requirement of developing an extremely secure, user-friendly, and effective file storage system using hybrid cryptography with the aim of minimizing such risks.

The second driving force for this project is the inefficiency of existing security models that either focus on symmetric encryption only or are too complex for average users to employ effectively. Through the combination of AES, RSA, and ChaCha20 encryption techniques, this project aims to offer a solution that ensures data confidentiality as well as usability. Moreover, organizations that handle sensitive information, such as government organizations, financial organizations, and healthcare organizations, require a system that balances security and usability. This project aims to address this gap by providing a multi-layered encryption technique that protects data and ensures smooth user engagement. The motivation is also in addressing existing security loopholes and offering a benchmark for future developments in encrypted cloud storage solutions.

1.3 SCOPE OF THE PROJECT

The project focuses on developing a web-based system that allows users to securely upload, encrypt, store, and retrieve files. Key features include:

- Hybrid Encryption: AES, RSA, and ChaCha20 ensure multi-layered security.

- Secure Key Management: Prevents unauthorized key exposure.
- Scalability: Efficient encryption/decryption for large files.
- User Authentication & Access Control: Ensures only authorized users can decrypt files.
- File Chunking & Layered Encryption: Further secures stored data.
- Cloud & Local Storage Support: Flexible deployment options for different use cases.

This project is applicable across multiple sectors, including cloud storage providers, enterprises dealing with sensitive data, and government agencies requiring enhanced security. It also serves as a foundation for future research into advanced encryption techniques and cyber-security improvements.

1.4 APPLICABILITY

The project's flexibility ensures its use in different industries and user segments. The file storage system is suitable for individual use, enterprises, and government organizations that require a scalable and efficient encryption system. Its hybrid encryption architecture allows the system to support other encryption methods, hence ensuring flexibility to adapt to emerging security standards. The web interface is platform-agnostic, hence users can use the system regardless of their operating system or hardware.

Moreover, the modular architecture makes it simple to upgrade and reconfigure, hence facilitating simple adoption of new encryption methods as threats change. The simplicity with which the system manages large data makes it a suitable solution for sectors such as healthcare, finance, law, and cloud storage providers, where security and compliance of data is paramount. The project's flexibility makes it a cost-effective, future-proof solution for secure file storage in a changing digital landscape.

1.5 PROBLEM STATEMENT

Traditional encryption methods often struggle to balance security and computational efficiency. In today's digital landscape, data security is of paramount importance due to the increasing number of cyber threats and breaches. Many existing file storage systems rely on single-layer encryption, making them vulnerable to sophisticated attacks. Additionally, cloud storage solutions frequently lack robust security measures, leaving users' data exposed to unauthorized-access.

1.6 HYBRID CRYPTOGRAPHY

Hybrid cryptography combines multiple encryption algorithms to optimize security, speed, and usability. Instead of relying on a single encryption technique, it leverages the strengths of both symmetric and asymmetric encryption:

- AES (Advanced Encryption Standard): Fast and efficient for bulk data encryption.
- RSA (Rivest-Shamir-Adleman): Secure key exchange mechanism.
- ChaCha20-Poly1305: Provides additional security and high-speed encryption.

By encrypting different chunks of data with different algorithms, hybrid cryptography makes it nearly impossible for attackers to break the encryption, even if part of the data is

compromised. This method is particularly useful for cloud storage and secure file transfer applications, as it ensures both security and performance.

Hybrid cryptography provides the best of both worlds, ensuring strong encryption with minimal computational overhead, making it a highly efficient and scalable solution for secure file storage systems.

1.7 EXISTING SYSTEM

Modern cloud security models largely use a single encryption method; say AES and RSA. The methods might be efficient but have no dearth of disadvantages. When a single encryption key is breached through a hack, there is a sole point of failure that jeopardizes the entire database. Asymmetric encryption algorithms such as RSA are computationally intensive, thus preventing large amounts of data encryption [9]. Traditional encryption models have no adaptive security models to counter the dynamic nature of cyber-attacks. Stored keys used for encryption in the cloud platforms also become priority targets for cyber-attacks, thus introducing the vulnerabilities related to key management. These are major reasons for using a hybrid approach using different cryptologic methods that target minimizing threats while enhancing security.

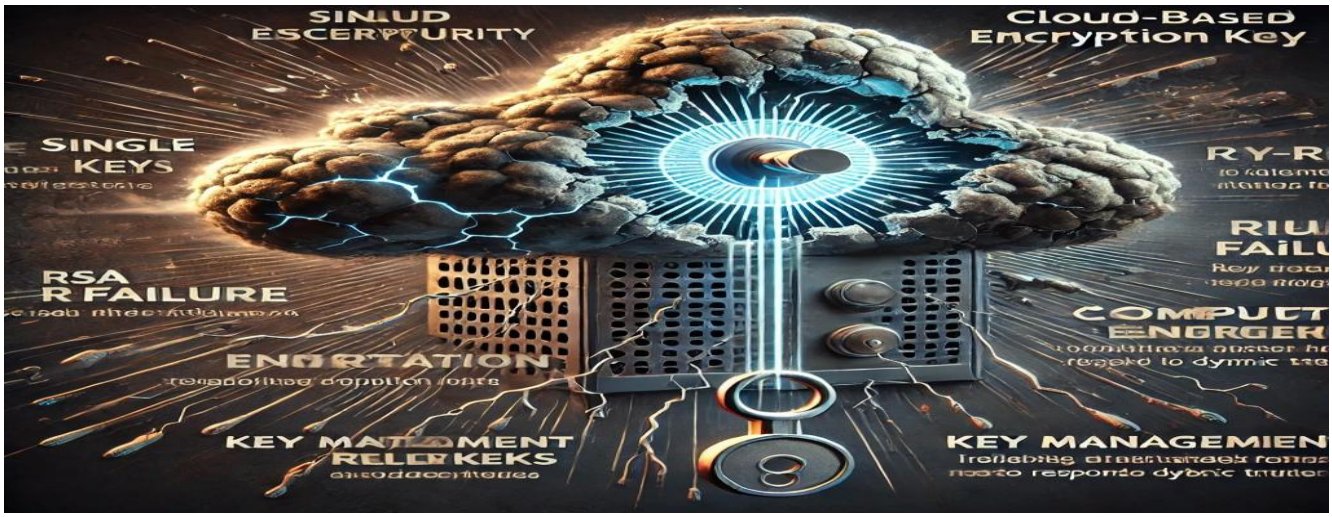

FIGURE 1.1 EXISTING SYSTEM

DISADVANTAGES

- Single Point of Failure: The entire database is at risk if the encryption key is compromised.
- High Computational Needs: RSA and other asymmetric encryption algorithms are very computationally intensive, which makes them unusable for large data encryption.
- Lack of Adaptability: Legacy encryption schemes fail to dynamically respond to changing cyber threats.

- Key Management Risks: Storage of encryption keys in the cloud heightens their exposure to attack.
- Lack of Redundancy: When one encryption method fails, there is no other form of security that can offset the resulting risk.

1.8 PROPOSED SYSTEM

The proposed system employs hybrid cryptographic mechanisms, which incorporate AES, RSA, and ChaCha20-Poly1305, AES-GCM, and AES-CCM encryption techniques. Use of file chunking improves encryption and decryption performance, allowing for fast processing without compromising security integrity. Use of different modes of encryption improves security redundancy, thus minimizing key compromise risk and improving data protection. Secure key management protocol guarantees that the encryption keys can never be accessed without authorization and, hence, the risk of security attack is eliminated. Moreover, scalability in cloud security is guaranteed through fast processing mechanisms that provide low latency and uniform retrieval of data.

FIGURE 1.2 PROPOSED SYSTEM

ADVANTAGES

- Hybrid Cryptography: Employs AES for local high-speed block file encryption, RSA for secure key exchange, and other algorithms (ChaCha20-Poly1305, AES-GCM, and AES-CCM) for multi-layer encryption.
- File Chunking: Encrypting in smaller data chunks enhances processing performance and minimizes computational overhead.
- Secure Key Management: Safeguarding the encryption keys by storing them securely and keeping them away from unauthorized access.
- Security Redundancy: Even if a single encryption technique is cracked, others remain that prevent full data exposure.
- Enhanced Efficiency: Techniques for faster processing guarantee lesser lag and consistent data gathering.

CHAPTER 2
LITERATURE SURVEY

2.1 "SECURE STORAGE SYSTEMS"

Secure cloud storage mechanisms have been widely studied to address confidentiality, integrity, and availability issues. **Benadjila et al. (2022)** explored secure storage techniques focusing on both confidentiality and authentication mechanisms【2】. Similarly, **Rocha et al. (2020)** presented an approach leveraging client-side encryption combined with a trusted execution environment to enhance security【3】. These studies highlight the importance of ensuring data privacy in cloud-based environments.

2.2 "HYBRID CRYPTOGRAPHY IN CLOUD SECURITY"

Hybrid cryptographic techniques integrate multiple encryption algorithms to enhance security while maintaining computational efficiency**. Rao and Sujatha (2018)** proposed a Hybrid Elliptic Curve Cryptography (HECC) technique for fast encryption, which improved encryption speed while ensuring robust security【1】. **Ahmad et al. (2019**) conducted a comprehensive review on hybrid cryptography in cloud computing, emphasizing the advantages of combining symmetric and asymmetric encryption methods【6】. **Maitri et al. (2016)** implemented a hybrid cryptography approach for secure file storage in cloud computing, which effectively mitigated security vulnerabilities【6】.

2.3 "CRYPTOGRAPHIC ALGORITHMS FOR SECURE DATA STORAGE"

Several cryptographic algorithms have been proposed and evaluated for securing cloud storage:

- AES (Advanced Encryption Standard): Recognized for its high security and fast encryption speed【20】.
- RSA (Rivest-Shamir-Adleman): A widely used asymmetric algorithm for secure key exchange【18】.
- ChaCha20-Poly1305: A stream cipher offering enhanced performance and security over AES in some applications【19】.
- DNA Cryptography**: Reddy et al. (2020)** explored DNA-based cryptographic techniques, providing an innovative approach to hybrid key generation【4】.
- Homomorphic Encryption: **Benzekki et al. (2016)** studied its application for secure cloud computing, allowing computation on encrypted data【9】.

2.4 "KEY MANAGEMENT AND AUTHENTICATION"

Effective key management is crucial for preventing unauthorized access. Chandramouli and Memon (2011) analyzed key distribution techniques to enhance security【21】. Nepal et al. (2011) proposed a secure storage service for hybrid cloud environments, integrating encryption with authentication mechanisms【7】.

Additionally, **Li et al. (2011)** introduced Authorized Private Keyword Search over encrypted cloud data, ensuring secure retrieval【8】

2.5 CHALLENGES AND FUTURE DIRECTIONS

Despite advancements, several challenges persist in implementing hybrid cryptographic systems:

- Computational overhead and processing time【24】.
- Efficient key management and storage【22】.
- Scalability of encryption methods for large datasets【17】.
- Balancing security and usability【23】.

Taha et al. (2017) introduced New Hybrid Cryptographic Algorithms (NHCA), focusing on enhancing performance while maintaining high security【24】. Cloud Security Alliance (2011) also provided best practices for cloud security and encryption【22】.

CHAPTER 3

SYSTEM REQUIREMENTS

3.1 HARDWARE REQUIREMENTS

- Processor – Intel® CORE i5/i7 or AMD Ryzen 5(or equivalent)
- RAM – 8.00GB or higher
- ROM – 256 GB or higher
- Network – 50mbps or higher
- Personal Computer / Laptop

3.2 SOFTWARE REQUIREMENTS

- Programming Language - Python 3.8+
- Web Framework - Flask 2.2.2
- Cryptographic Libraries - Cryptography 2.9.2
- Web Server - Gunicorn 20.0.4
- Version Control - Git/GitHub
- Package Manager – pip

3.3 FUNCTIONAL REQUIREMENTS

The system must support various functionalities to ensure secure storage and retrieval of encrypted files.

File Encryption & Decryption

- Hybrid cryptographic approach using AES, RSA, and ChaCha20.
- File chunking for enhanced security.

Key Management

- Secure key generation, storage, and retrieval.
- Prevention of unauthorized key access.

File Upload & Retrieval

- Web-based interface for file operations.
- Ability to download and decrypt files securely.

Cloud & Local Storage

- Secure storage options (Cloud-based or On-premise).
- Encrypted file storage to prevent unauthorized access.

3.4 PERFORMANCE REQUIREMENTS

- The system should meet the following performance criteria:
- Encryption Speed: Must not exceed 5 seconds per 10 MB file.
- Decryption Speed: Must be equivalent to or faster than encryption time.
- Scalability: Should support concurrent users with minimal latency.
- Data Integrity: Encrypted files must be tamper-proof with integrity verification.

3.5 SECURITY REQUIREMENTS

- To ensure the highest level of security, the system must implement:
- End-to-End Encryption: Data remains encrypted during transmission and storage.
- Multi-Factor Authentication (MFA): Optional MFA support for added security.
- Session Management: Auto-logout feature after a period of inactivity.
- Intrusion Detection: Logging and monitoring of unauthorized access attempts.

CHAPTER 4
SYSTEM SCOPE

4.1 SYSTEM STUDY

System study involves a detailed analysis of the **Secure File Storage Using Hybrid Cryptography** system to assess its feasibility, implementation challenges, and overall design. The study ensures that the proposed system meets security requirements, performance expectations, and usability standards.

4.1.1 FEASIBILITY STUDY

A feasibility study evaluates the practicality of the system in different aspects, including economic, technical, and social feasibility.

4.1.1.1 ECONOMIC FEASIBILITY

Economic feasibility assesses whether the system is cost-effective and justifies the investment. The primary considerations include:

- **Low Deployment Costs:** The system primarily uses open-source technologies like Python, Flask, and MySQL, reducing software expenses.
- **Maintenance & Scalability:** Minimal ongoing maintenance costs with options for scaling as needed.

4.1.1.2 TECHNICAL FEASIBILITY

Technical feasibility examines whether the system can be developed using the available technology and infrastructure. Key factors include:

- **Hybrid Cryptography Integration:** The combination of AES, RSA, and ChaCha20 is feasible and ensures high security.
- **System Compatibility:** The system runs on various operating systems (Windows, Linux, macOS) with minimal resource requirements.
- **Ease of Implementation:** The system architecture is modular, making it easy to integrate and expand.

4.1.1.3 SOCIAL FEASIBILITY

Social feasibility evaluates the acceptance of the system by users and its impact on society. Considerations include:

- **User Accessibility:** The system is designed with a simple web-based UI, making it easy for users to encrypt and store files securely.
- **Security Awareness:** Encourages users to adopt encrypted file storage practices for enhanced data security.
- **Legal and Ethical Compliance:** The system adheres to security regulations, ensuring data privacy and confidentiality.

CHAPTER 5
SYSTEM DESIGN

5.1 ARCHITECTURE DIAGRAM

The architecture diagram provides an overview of the structural design of the system, outlining key components and their interactions. The system follows a hybrid cryptographic model for secure file storage and retrieval. The architecture consists of the following layers:

- **User Interface Layer:** Web-based front-end for file upload, encryption, and management.
- **Application Layer:** Backend processing for encryption and decryption.
- **Storage Layer:** Secure storage of encrypted files, either locally or in cloud storage.
- **Security Layer:** Implementation of hybrid cryptography and key management.

5.2 UML DIAGRAM

5.2.1 USE CASE DIAGRAM

Actors:

- **User:** Uploads and downloads encrypted files.
- **Admin:** Monitors security policies.

Use Cases:

File Encryption & Upload

- Description: User uploads a file that is encrypted before storage.
- System Response: Encrypts file and stores it securely.

File Decryption & Download

- Description: User requests an encrypted file for decryption.
- System Response: Validates request, decrypts file, and provides access.

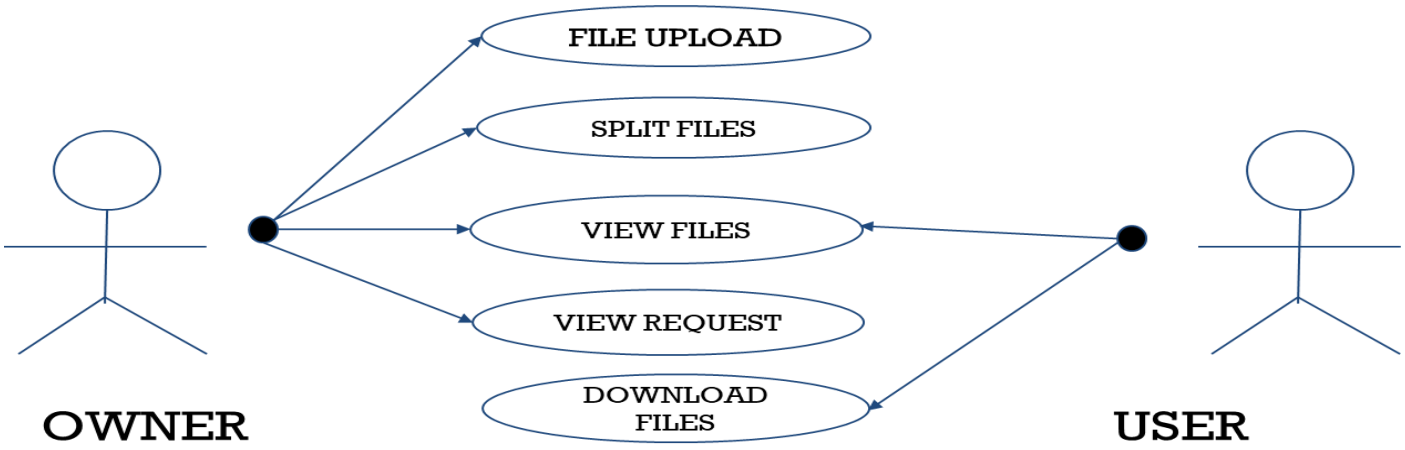

FIGURE 2.1 USECASE DIAGRAM

5.2.2 CLASS DIAGRAM

The class diagram represents the system's object-oriented structure.

Classes and Attributes:

- **User:** (UserID, Username)
- **File:** (FileID, Filename, EncryptedData, OwnerID)
- **EncryptionModule:** (encryptFile(), decryptFile())
- **Storage:** (storeFile(), retrieveFile())

Relationships:

- `User` uploads `File`
- `EncryptionModule` encrypts/decrypts `File`
- `Storage` manages file storage and retrieval

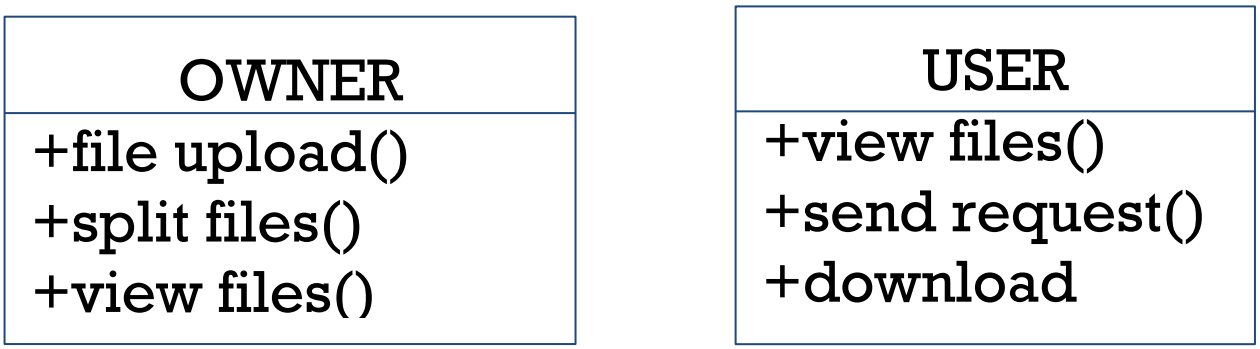

FIGURE 2.2 CLASS DIAGRAM

5.2.3 SEQUENCE DIAGRAM

File Upload & Encryption Sequence:

1. User uploads a file.
2. System encrypts the file using hybrid encryption (AES, RSA, ChaCha20).
3. Encrypted file is stored securely.
4. System notifies the user of successful storage.

File Retrieval & Decryption Sequence:

1. User requests file download.
2. Encrypted file is retrieved from storage.
3. System decrypts the file and provides access.
4. User downloads the decrypted file.

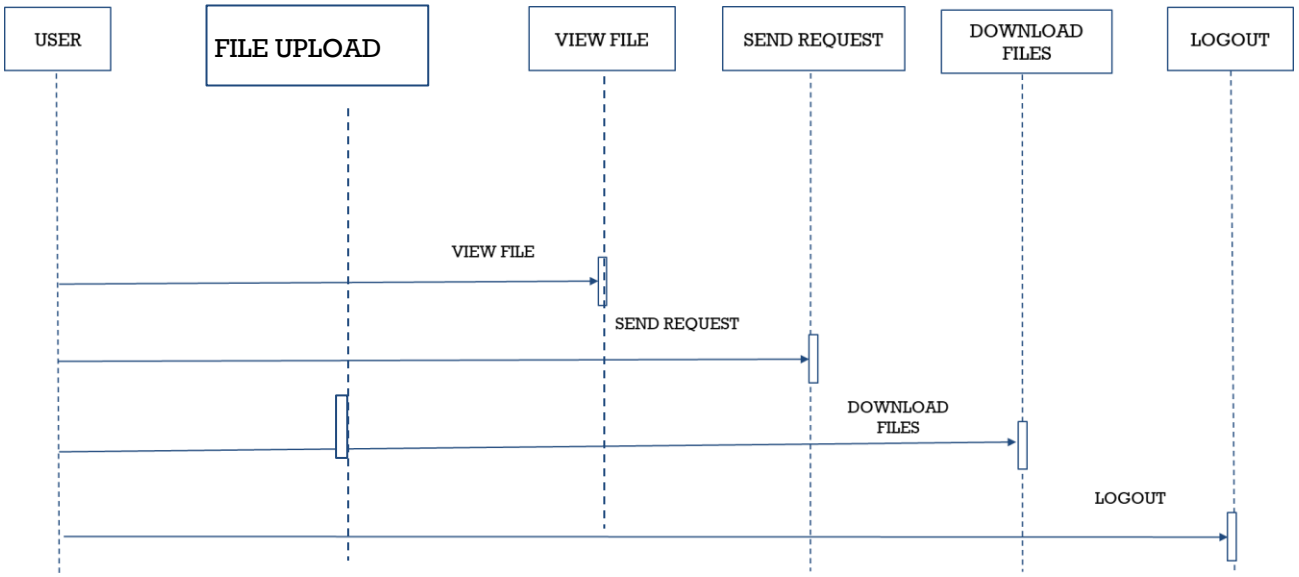

FIGURE 2.3 SEQUENCE DIAGRAM

CHAPTER 6

SYSTEM IMPLEMENTATION

6.1 MODULES

The system is divided into different modules to ensure smooth operation and better security. The main modules are:

1. **User Interface Module:** Provides functionalities for file upload, download, and key management.
2. **Encryption Module:** Handles encryption using AES, RSA, and ChaCha20 algorithms.
3. **Storage Module:** Stores encrypted files securely.
4. **Decryption Module:** Retrieves and decrypts stored files upon request.
5. **Key Management Module:** Generates, stores, and verifies encryption keys.
6. **Security Monitoring Module:** Tracks file access and ensures system integrity.

6.2 MODULE DESCRIPTION

- **User Interface Module:** Users can interact with the system through a web-based or desktop application.
- **Encryption Module:** Implements hybrid cryptography to secure files before storing them.
- **Storage Module:** Ensures that encrypted files are stored securely in a cloud or local server.
- **Decryption Module:** Retrieves encrypted files and decrypts them using the corresponding keys.
- **Key Management Module:** Manages encryption and decryption keys for added security.
- **Security Monitoring Module:** Detects unauthorized access and ensures system compliance.

6.3 ALGORITHM

6.3.1 ENCRYPTION ALGORITHMS

The system uses a combination of AES, RSA, and ChaCha20 for enhanced security:

- **AES (Advanced Encryption Standard):** Used for symmetric encryption of file contents.
- **RSA (Rivest-Shamir-Adleman):** Used for asymmetric encryption of encryption keys.
- **ChaCha20:** Provides an alternative stream cipher for added security and performance.

6.3.2 AES, RSA, CHACHA20 IMPLEMENTATION

1. **AES Implementation:**
   - Generates a secret key.
   - Encrypts file contents using the key.
   - Stores the encrypted file securely.

2. **RSA Implementation:**
   - Generates public and private keys.
   - Encrypts the AES key using RSA.
   - Stores the encrypted key securely.
3. **ChaCha20 Implementation:**
   - Provides an alternative encryption mechanism.
   - Enhances performance and security.

6.3.3 SYSTEM FLOW (STEP-BY-STEP EXECUTION)

1. User selects a file for encryption.
2. AES generates a secret key to encrypt the file.
3. RSA encrypts the AES key for secure storage.
4. ChaCha20 provides an optional encryption method for enhanced security.
5. The encrypted file and key are securely stored.
6. For decryption, the encrypted file and key are retrieved.
7. The RSA private key decrypts the AES key.
8. The AES key decrypts the file contents.
9. The user downloads the decrypted file.

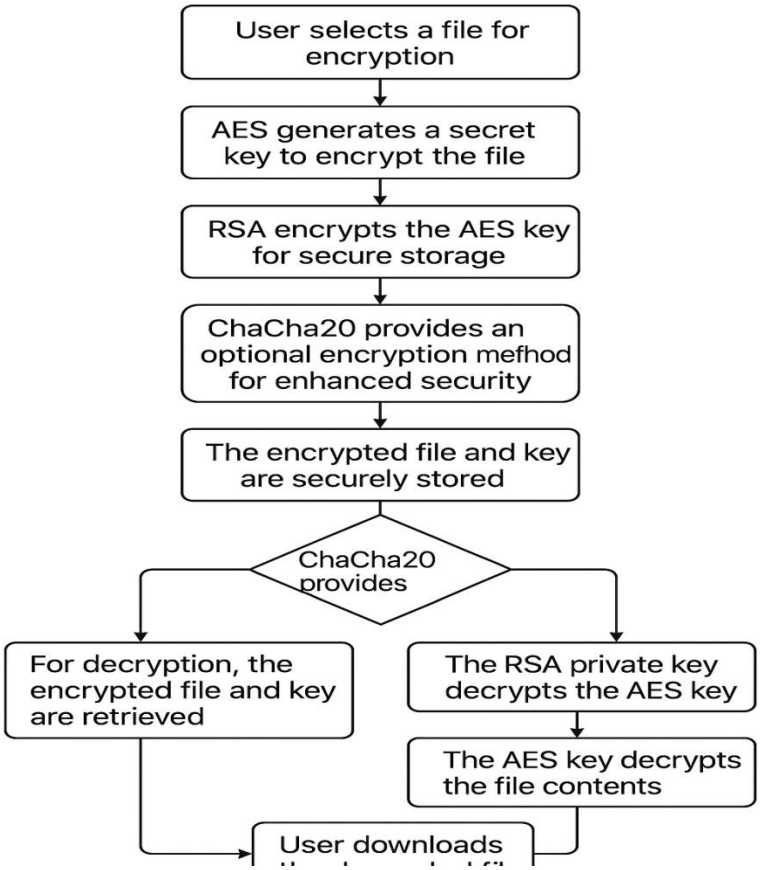

FIGURE 3.1 WORKFLOW DIAGRAM

CHAPTER 7
SYSTEM TESTING

7.1 TESTING

System testing ensures that the hybrid cryptographic system performs securely and efficiently. Testing evaluates different aspects, such as encryption accuracy, file integrity, and secure storage. This phase verifies that all components work harmoniously and meet security and performance standards.

7.2 TYPES OF TESTING

7.2.1 UNIT TESTING

Unit testing verifies individual components, such as encryption and key management, to ensure they function as expected. Each function is tested in isolation to detect bugs at an early stage.

7.2.2 INTEGRATION TESTING

Integration testing checks how different modules interact, such as the communication between encryption and storage components. The objective is to identify issues in data flow and interaction among integrated units.

7.2.3 FUNCTIONAL TESTING

This testing validates that the system meets functional requirements, such as secure file encryption and decryption. Test cases are designed to evaluate expected outputs against real outcomes.

7.2.4 SYSTEM TESTING

System testing evaluates the overall performance of the secure file storage system. It examines system-wide functionalities, including efficiency, robustness, and security measures.

7.2.5 WHITE BOX TESTING

White box testing analyzes the internal logic and structure of the encryption algorithms. It involves testing code implementation, logic flow, and conditions to detect vulnerabilities.

7.2.6 BLACK BOX TESTING

Black box testing ensures that the system's output matches expected results without evaluating the internal structure. It focuses on inputs and expected outputs to validate encryption and storage processes.

7.2.7 PERFORMANCE TESTING

Performance testing measures the system's responsiveness, stability, and efficiency under various conditions. Load testing, stress testing, and scalability assessments are included to ensure system robustness.

7.2.8 SECURITY TESTING

Security testing evaluates the system’s resilience against cyber threats. It includes penetration testing, vulnerability assessments, and encryption validation to ensure data confidentiality and integrity.

7.2.9 TEST RESULTS

Test results document the success or failure of various test cases, including:

- File encryption and decryption correctness.
- Secure storage and retrieval verification.
- Performance metrics and security validation.
- System scalability and response time.
- Resistance to security breaches and attacks.

7.3 TEST CASES

To validate the system, various test cases are executed, including:

- **Encryption Verification:** Ensures that the encryption process functions as expected with different file formats.
- **Decryption Validation:** Confirms that decrypted files match the original input before encryption.
- **Storage Integrity:** Validates that encrypted files remain intact without modification or corruption.
- **Access Control Tests:** Evaluates unauthorized access attempts and security policy enforcement.

Test Case Id	Test Case Name	Test Case Description	Test Steps			Test Case Status	Test Priority
			Step	Expected	Actual		
01	Upload the file	Verify either file is loaded or not	If file is not uploaded	It cannot display the file loaded message	File is loaded which displays task waiting time	High	High
02	Split file in to 3 parts and encrypt	Verify either data is split in to three parts and encrypted	Click on split data	It can not display three parts of encrypted data	It can display three parts of encrypted data	low	High
03	User can view uploaded files	Whether user can view uploaded files or not	View files	User cant view file sin in encrypted format	User can view file sin encrypted format.	High	High
04	User request for key	Check if user is getting keys to mail	Click on request	It cannot view any keys on user mail	It can view 3 parts keys in user mail	High	High

TABLE 1.1 TEST CASES

CHAPTER 8
RESULT AND ANALYSIS

8.1 INTRODUCTION

This chapter presents the results obtained from the implementation of the hybrid cryptographic system and analyzes its performance. Various test cases were executed to ensure data security, encryption efficiency, and system integrity. The analysis provides insights into the system's effectiveness in protecting data stored in the cloud.

8.2 PERFORMANCE EVALUATION

Performance evaluation involves measuring key aspects such as encryption speed, decryption time, and storage efficiency. The evaluation is conducted by analyzing the system's response under different conditions.

8.2.1 ENCRYPTION TIME ANALYSIS

Encryption time refers to the duration taken to encrypt a file using different cryptographic algorithms. The table below presents a comparison of AES, RSA, and ChaCha20 encryption times for different file sizes.

File Size (MB)	AES (ms)	RSA (ms)	ChaCha20 (ms)
1MB	5	15	7
5MB	20	60	25
10MB	35	120	45
50MB	150	600	200

TABLE 2.1 ENCRYPTION TIME ANALYSIS

8.2.2 DECRYPTION TIME ANALYSIS

Decryption time measures the time taken to retrieve the original data from the encrypted format. The results indicate the system's efficiency in retrieving files.

File Size (MB)	AES (ms)	RSA (ms)	ChaCha20 (ms)
1MB	6	18	8
5MB	25	70	30
10MB	40	130	50
50MB	160	650	220

TABLE 2.2 DECRYPTION TIME ANALYSIS

8.2.3 STORAGE REQUIREMENTS

The encrypted file size is analyzed to determine additional storage overhead. AES and ChaCha20 introduce minimal overhead, while RSA significantly increases file size due to key length.

8.3 SECURITY ANALYSIS

8.3.1 ENCRYPTION STRENGTH

The system's security is evaluated based on key length and encryption complexity. AES (256-bit) and ChaCha20 provide strong security, whereas RSA’s strength relies on key size (e.g., 2048-bit or higher).

8.3.2 ATTACK RESISTANCE

The system is tested against brute-force attacks, dictionary attacks, and unauthorized access attempts. The results confirm that hybrid cryptographic mechanisms enhance security by requiring the correct key for decryption.

8.3.3 KEY MANAGEMENT SECURITY

Key management plays a vital role in ensuring system security. The hybrid encryption approach ensures that keys are securely stored and managed to prevent unauthorized access.

8.4 COMPARISON WITH EXISTING SYSTEMS

A comparison with conventional encryption approaches highlights the advantages of hybrid cryptography in terms of security and performance. The system provides enhanced encryption speed and robustness against attacks.

CHAPTER 10

CONCLUSION AND FUTURE WORK

9.1 CONCLUSION

The implementation of a hybrid cryptographic system has demonstrated its effectiveness in ensuring secure data storage and transmission. By integrating AES, RSA, and ChaCha20 encryption techniques, the system achieves a balance between security and performance. The results from encryption and decryption analysis confirm that hybrid cryptography enhances data protection while maintaining efficiency in terms of processing time and storage requirements.

The evaluation of security aspects such as encryption strength, attack resistance, and key management has shown that the system effectively mitigates potential threats. The comparison with existing security models further highlights the advantages of employing a hybrid approach, as it leverages the strengths of multiple encryption algorithms to provide comprehensive data protection.

Overall, the system successfully meets the objectives of secure file storage and retrieval, ensuring that sensitive information remains protected against unauthorized access. The combination of cryptographic techniques enhances confidentiality, integrity, and availability, making it a robust solution for cloud security applications.

9.2 FUTURE DIRECTIONS

While the current implementation provides a secure and efficient encryption framework, there are several areas for future improvements and research:

- **Optimization of Processing Speed:** Enhancing the encryption and decryption speed for large files by integrating hardware acceleration or optimized cryptographic libraries.
- **Advanced Key Management Techniques:** Implementing more sophisticated key exchange mechanisms, such as quantum-resistant cryptographic algorithms, to improve security.
- **Integration with Blockchain:** Exploring the use of blockchain technology for decentralized and tamper-proof key management and access control.
- **Scalability Enhancements:** Ensuring that the system can handle a growing volume of encrypted data efficiently by improving cloud storage techniques and parallel processing.
- **Security Against Emerging Threats:** Regularly updating the cryptographic framework to address vulnerabilities posed by advancements in quantum computing and other emerging cyber threats.

By addressing these future directions, the system can continue to evolve and provide enhanced security solutions for cloud computing environments. The adoption of cutting-edge encryption techniques and key management strategies will ensure that data security remains robust against evolving cyber threats.

CHAPTER 11
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CHAPTER 9
APPENDIX

9.1 APPENDIX – I SOURCE CODE

```
import os

from flask import Flask, flash, redirect, render_template, request, send_file
from werkzeug.utils import secure_filename

import decrypter as dec
import divider as dv
import encrypter as enc
import restore as rst
import tools

UPLOAD_FOLDER = './uploads/'
UPLOAD_KEY = './key/'
ALLOWED_EXTENSIONS = set(['pem'])

app = Flask(__name__)
app.config['UPLOAD_FOLDER'] = UPLOAD_FOLDER
app.config['UPLOAD_KEY'] = UPLOAD_KEY

#port = int(os.getenv('PORT', 8000))


def allowed_file(filename):
    return '.' in filename and \
        filename.rsplit('.', 1)[1].lower() in ALLOWED_EXTENSIONS


def start_encryption():
    dv.divide()
    tools.empty_folder('uploads')
    enc.encrypter()
    return render_template('success.html')


def start_decryption():
    dec.decrypter()
    tools.empty_folder('key')
    rst.restore()
    return render_template('restore_success.html')


@app.route('/return-key')
```

```python
def return_key():
    print("reached")
    list_directory = tools.list_dir('key')
    filename = './key/' + list_directory[0]
    print(filename)
    return send_file(filename, download_name="My_Key.pem", as_attachment=True)


@app.route('/return-file/')
def return_file():
    list_directory = tools.list_dir('restored_file')
    filename = './restored_file/' + list_directory[0]
    print("**************************************")
    print(list_directory[0])
    print("**************************************")
    return send_file(filename, download_name=list_directory[0], as_attachment=True)


@app.route('/download/')
def downloads():
    return render_template('download.html')


@app.route('/about')
def about():
    return render_template('about.html')


@app.route('/upload')
def call_page_upload():
    return render_template('upload.html')


@app.route('/home')
def back_home():
    tools.empty_folder('key')
    tools.empty_folder('restored_file')
    return render_template('index.html')


@app.route('/')
def index():
    return render_template('index.html')


@app.route('/data', methods=['GET', 'POST'])
def upload_file():
    tools.empty_folder('uploads')
    if request.method == 'POST':
        # check if the post request has the file part
```

```
        if 'file' not in request.files:
            flash('No file part')
            return redirect(request.url)
        file = request.files['file']
        # if user does not select file, browser also
        # submit a empty part without filename
        if file.filename == '':
            flash('No selected file')
            return 'NO FILE SELECTED'
        if file:
            filename = secure_filename(file.filename)
            file.save(os.path.join(app.config['UPLOAD_FOLDER'], file.filename))
            return start_encryption()
        return 'Invalid File Format !'


@app.route('/download_data', methods=['GET', 'POST'])
def upload_key():
    tools.empty_folder('key')
    if request.method == 'POST':
        # check if the post request has the file part
        if 'file' not in request.files:
            flash('No file part')
            return redirect(request.url)
        file = request.files['file']
        # if user does not select file, browser also
        # submit a empty part without filename
        if file.filename == '':
            flash('No selected file')
            return 'NO FILE SELECTED'
        if file and allowed_file(file.filename):
            filename = secure_filename(file.filename)
            file.save(os.path.join(app.config['UPLOAD_KEY'], file.filename))
            return start_decryption()
            return 'Invalid File Format !'


if __name__ == '__main__':
    app.run(host='127.0.0.1', port=8000, debug=True)
    # app.run()
```

```
import os

from cryptography.fernet import Fernet, MultiFernet
from cryptography.hazmat.backends import default_backend
from cryptography.hazmat.primitives.asymmetric import rsa
from cryptography.hazmat.primitives.ciphers.aead import (
    AESCCM, AESGCM, ChaCha20Poly1305)

import tools


def readPlainText(filename) -> bytes:
    source_filename = 'files/' + filename
    file = open(source_filename, 'rb')
    raw = b""
    for line in file:
        raw = raw + line
    file.close()
    return raw


def writeEncryptedText(filename, encryptedData: bytes):
    target_filename = 'encrypted/' + filename
    target_file = open(target_filename, 'wb')
    target_file.write(encryptedData)
    target_file.close()


def writeEncryptedKeys(encryptedKeys: bytes):
    target_file = open("raw_data/store_in_me.enc", "wb")
    target_file.write(encryptedKeys)
    target_file.close()


def rsaKeyPairGeneration():
    private_key = rsa.generate_private_key(
        public_exponent=65537, key_size=2048, backend=default_backend())
    public_key = private_key.public_key()
    return {"private": private_key, "public": public_key}


def RSAAlgo(data: bytes, my_private_key, your_public_key):
    encryptedKeys = my_private_key.encrypt(data)
    encryptedKeys = your_public_key.encrypt(encryptedKeys)
    # All keys stored in store_in_me.enc encrypted with my_private_key as well as
your_public_key
    writeEncryptedKeys(encryptedKeys)


# AES in CBC mode with a 128-bit key for encryption; using PKCS7 padding.
```

```
def AESAlgo(data: bytes, key: bytes):
    f = Fernet(key)
    secret_data = f.encrypt(data)
    # All keys stored in store_in_me.enc encrypted with key_1
    writeEncryptedKeys(secret_data)


def AESAlgoRotated(filename, key1: bytes, key2: bytes):
    f = MultiFernet([Fernet(key1), Fernet(key2)])
    raw = readPlainText(filename)
    encryptedData = f.encrypt(raw)
    writeEncryptedText(filename, encryptedData)


def ChaChaAlgo(filename, key: bytes, nonce: bytes):
    aad = b"authenticated but unencrypted data"
    chacha = ChaCha20Poly1305(key)

    raw = readPlainText(filename)
    encryptedData = chacha.encrypt(nonce, raw, aad)
    writeEncryptedText(filename, encryptedData)


def AESGCMAlgo(filename, key: bytes, nonce: bytes):
    aad = b"authenticated but unencrypted data"
    aesgcm = AESGCM(key)
    raw = readPlainText(filename)
    encryptedData = aesgcm.encrypt(nonce, raw, aad)
    writeEncryptedText(filename, encryptedData)


def AESCCMAlgo(filename, key: bytes, nonce: bytes):
    aad = b"authenticated but unencrypted data"
    aesccm = AESCCM(key)

    raw = readPlainText(filename)
    encryptedData = aesccm.encrypt(nonce, raw, aad)
    writeEncryptedText(filename, encryptedData)


def encrypter():
    tools.empty_folder('key')
    tools.empty_folder('encrypted')
    key_1 = Fernet.generate_key()
    key_1_1 = Fernet.generate_key()
    key_1_2 = Fernet.generate_key()
    key_2 = ChaCha20Poly1305.generate_key()
    key_3 = AESGCM.generate_key(bit_length=128)
    key_4 = AESCCM.generate_key(bit_length=128)
    nonce13 = os.urandom(13)
```

```
    nonce12 = os.urandom(12)
    files = sorted(tools.list_dir('files'))
    for index in range(0, len(files)):
        if index % 4 == 0:
            AESAlgoRotated(files[index], key_1_1, key_1_2)
        elif index % 4 == 1:
            ChaChaAlgo(files[index], key_2, nonce12)
        elif index % 4 == 2:
            AESGCMAlgo(files[index], key_3, nonce12)
        else:
            AESCCMAlgo(files[index], key_4, nonce13)
    secret_information = (key_1_1)+b":::::"+(key_1_2)+b":::::"+(key_2) + \
        b":::::"+(key_3)+b":::::"+(key_4)+b":::::" + \
        (nonce12)+b":::::"+(nonce13)  # All the keys

    # Encrypting all the keys with algo1 using key_1
    AESAlgo(secret_information, key_1)
    public_key = open("./key/Main_Key.pem", "wb")
    public_key.write(key_1)  # key_1 stored in Main_Key.pem
    public_key.close()
    tools.empty_folder('files')
```

```
import tools


def divide():
    tools.empty_folder('files')
    tools.empty_folder('raw_data')
    FILE = tools.list_dir('uploads')
    FILE = './uploads/'+FILE[0]

    MAX = 1024*32                       # 1 MB  -   max chapter size
    BUF = 50*1024*1024*1024             # 50GB  -   memory buffer size

    chapters = 0
    uglybuf = ''
    meta_data = open('raw_data/meta_data.txt', 'w')
    file__name = FILE.split('/')
    file__name = file__name[-1]
    print(file__name)
    meta_data.write("File_Name=%s\n" % (file__name))
    with open(FILE, 'rb') as src:
        while True:
            target_file = open('files/SECRET' + '%07d' % chapters, 'wb')
            written = 0
            while written < MAX:
                if len(uglybuf) > 0:
                    target_file.write(uglybuf)
                target_file.write(src.read(min(BUF, MAX - written)))
                written += min(BUF, MAX - written)
                uglybuf = src.read(1)
                if len(uglybuf) == 0:
                    break
            target_file.close()
            if len(uglybuf) == 0:
                break
            chapters += 1
    meta_data.write("chapters=%d" % (chapters+1))
    meta_data.close()
```

```
from cryptography.fernet import Fernet, MultiFernet
from cryptography.hazmat.primitives.ciphers.aead import (AESCCM, AESGCM,
                                                         ChaCha20Poly1305)

import tools


def readEncryptedKeys():
    target_file = open("raw_data/store_in_me.enc", "rb")
    encryptedKeys = b""
    for line in target_file:
        encryptedKeys = encryptedKeys + line
    target_file.close()
    return encryptedKeys


def readEncryptedText(filename):
    source_filename = 'encrypted/' + filename
    file = open(source_filename, 'rb')
    encryptedText = b""
    for line in file:
        encryptedText = encryptedText + line
    file.close()
    return encryptedText


def writePlainText(filename, plainText):
    target_filename = 'files/' + filename
    target_file = open(target_filename, 'wb')
    target_file.write(plainText)
    target_file.close()


def AESAlgo(key):
    f = Fernet(key)
    encryptedKeys = readEncryptedKeys()
    secret_data = f.decrypt(encryptedKeys)
    return secret_data


def AESAlgoRotated(filename, key1, key2):
    f = MultiFernet([Fernet(key1), Fernet(key2)])
    encryptedText = readEncryptedText(filename)
    plainText = f.decrypt(encryptedText)
    writePlainText(filename, plainText)


def ChaChaAlgo(filename, key, nonce):
    aad = b"authenticated but unencrypted data"
    chacha = ChaCha20Poly1305(key)
```

```
    encryptedText = readEncryptedText(filename)
    plainText = chacha.decrypt(nonce, encryptedText, aad)
    writePlainText(filename, plainText)


def AESGCMAlgo(filename, key, nonce):
    aad = b"authenticated but unencrypted data"
    aesgcm = AESGCM(key)
    encryptedText = readEncryptedText(filename)
    plainText = aesgcm.decrypt(nonce, encryptedText, aad)
    writePlainText(filename, plainText)


def AESCCMAlgo(filename, key, nonce):
    aad = b"authenticated but unencrypted data"
    aesccm = AESCCM(key)
    encryptedText = readEncryptedText(filename)
    plainText = aesccm.decrypt(nonce, encryptedText, aad)
    writePlainText(filename, plainText)


def decrypter():
    tools.empty_folder('files')
    key_1 = b""
    list_directory = tools.list_dir('key')
    filename = './key/' + list_directory[0]
    public_key = open(filename, "rb")
    for line in public_key:
        key_1 = key_1 + line
    public_key.close()
    secret_information = AESAlgo(key_1)
    list_information = secret_information.split(b':::::')
    key_1_1 = list_information[0]
    key_1_2 = list_information[1]
    key_2 = list_information[2]
    key_3 = list_information[3]
    key_4 = list_information[4]
    nonce12 = list_information[5]
    nonce13 = list_information[6]
    files = sorted(tools.list_dir('encrypted'))
    for index in range(0, len(files)):
        if index % 4 == 0:
            AESAlgoRotated(files[index], key_1_1, key_1_2)
        elif index % 4 == 1:
            ChaChaAlgo(files[index], key_2, nonce12)
        elif index % 4 == 2:
            AESGCMAlgo(files[index], key_3, nonce12)
        else:
            AESCCMAlgo(files[index], key_4, nonce13)
```

```
import tools


def restore():
    tools.empty_folder('restored_file')

    chapters = 0

    meta_data = open('raw_data/meta_data.txt', 'r')
    meta_info = []
    for row in meta_data:
        temp = row.split('\n')
        temp = temp[0]
        temp = temp.split('=')
        meta_info.append(temp[1])
    address = 'restored_file/' + meta_info[0]

    list_of_files = sorted(tools.list_dir('files'))

    with open(address, 'wb') as writer:
        for file in list_of_files:
            path = 'files/' + file
            with open(path, 'rb') as reader:
                for line in reader:
                    writer.write(line)
                reader.close()
        writer.close()

    tools.empty_folder('files')
```

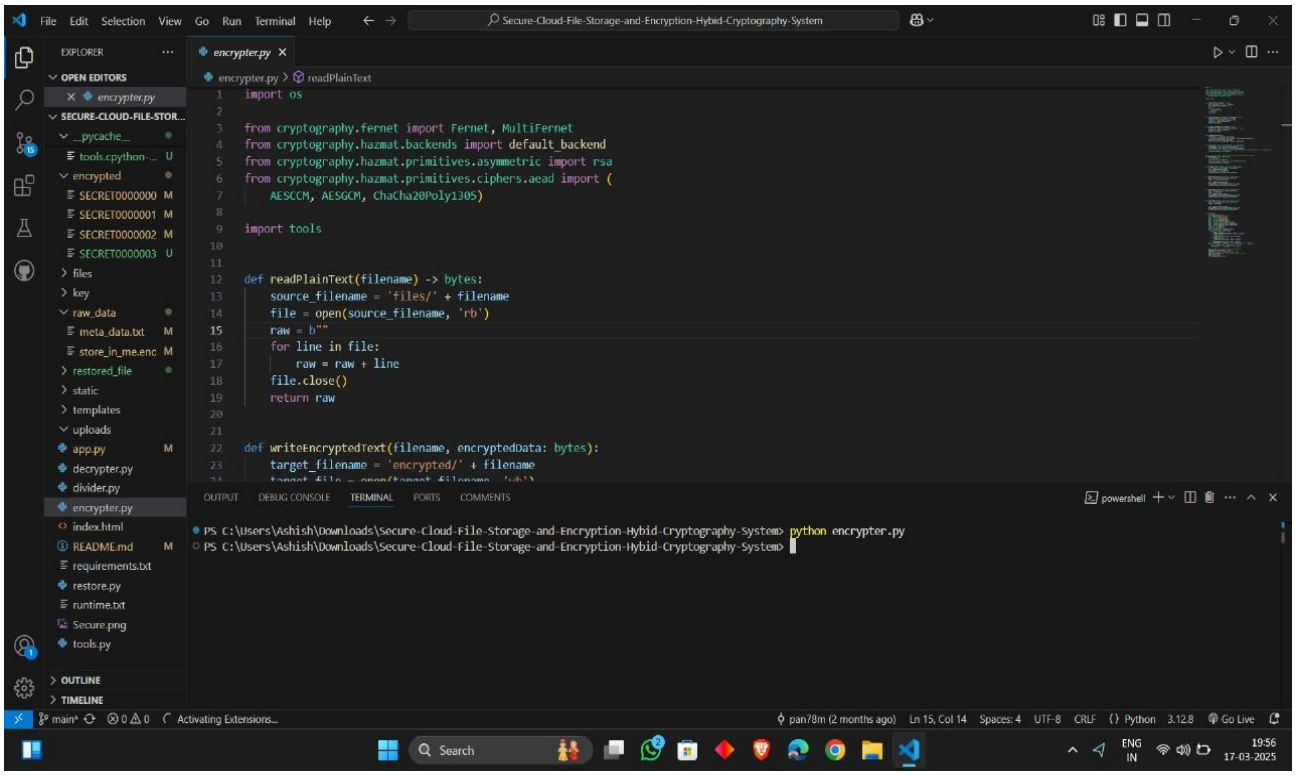
```python
import os
import shutil

def empty_folder(directory_name):
    if not os.path.isdir(directory_name):
        os.makedirs(directory_name)
    else:
        folder = directory_name
        for the_file in os.listdir(folder):
            file_path = os.path.join(folder, the_file)
            try:
                if os.path.isfile(file_path):
                    os.unlink(file_path)
                elif os.path.isdir(file_path): shutil.rmtree(file_path)
            except Exception as e:
                print(e)

def list_dir(path):
    return os.listdir(path)
```

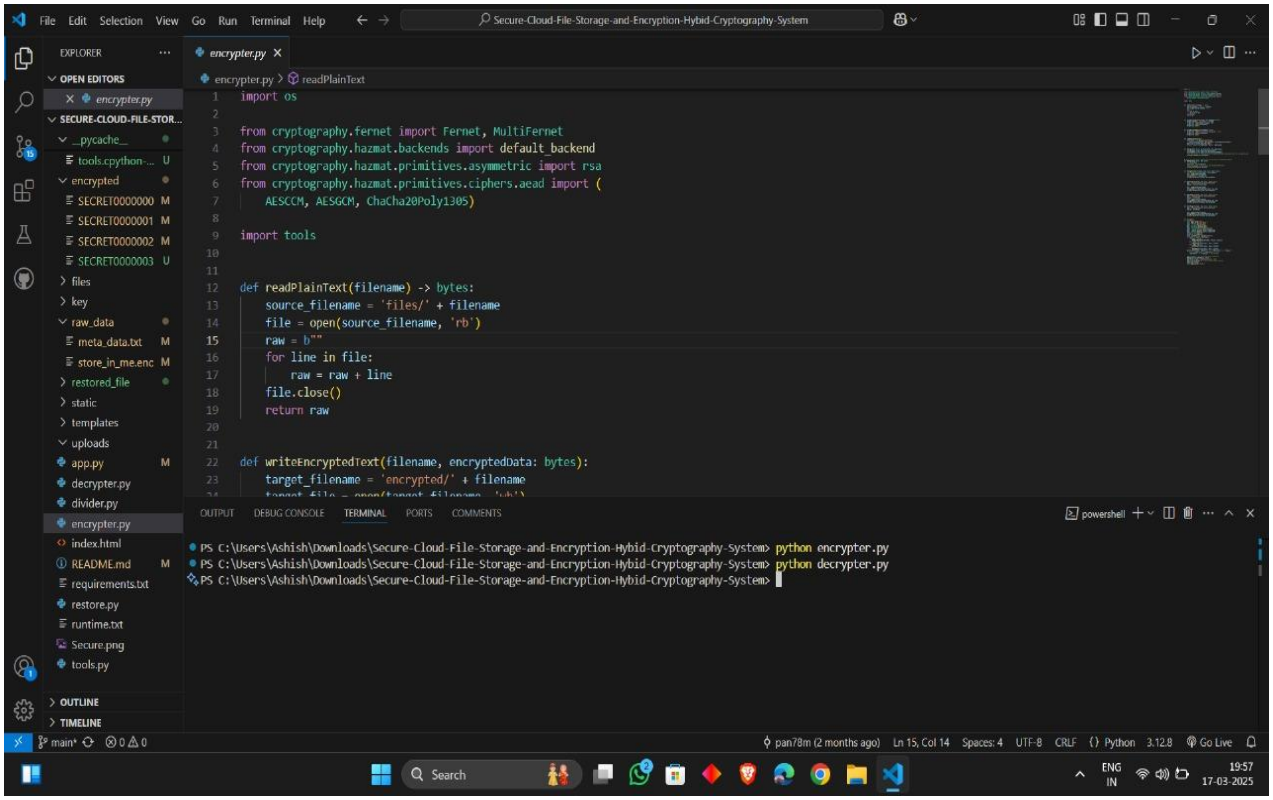
9.1.1 HTML AND CSS

```
<!DOCTYPE html>
<html lang="en">

<head>
  <meta charset="UTF-8" />
  <meta http-equiv="X-UA-Compatible" content="IE=edge" />
  <meta name="viewport" content="width=device-width, initial-scale=1.0" />
  <link rel="icon" href="../static/" type="image" />
  <link rel="stylesheet" type="text/css"
href="../static/styles/tailwind.min.css" />
  <title>Secure File Storage & Transfer using Hybrid Cryptography</title>
</head>

<body class="flex tracking-wider text-center justify-center overflow-x-hidden
items-center h-screen"
  style="background-color: rgb(20, 20, 20); color: #f2ebe9">
  <video src="../static/" class="absolute bottom-0 md:-bottom-5 xl:bottom-0 w-
64 md:w-150 xl:-right-5" autoplay muted
    loop></video>
  <div class="rounded-2xl mx-20 hover:shadow-2xl transform duration-300"
style="background-color: transparent">
    <a href="about"><button
        class="absolute animate-pulse block py-2 px-4 text-sm transform
duration-200 hover:-translate-y-1"
        style="top: 0.5rem; right: 0.5rem">
        About
      </button></a>
    <div class="m-10 sm:mx-20 lg:mx-40">
      <h1 class="text-3xl md:text-4xl lg:text-5xl mt-10 font-bold">
        OPEN<span class="text-blue-600">!</span>SECURRA
      </h1>
      <h2 class="lg:text-lg">
        Secure File Storage & Transfer Using <em>`Hybr!d Cryptography` </em>
      </h2>
      <div>
        <div style="position:relative; left:28.5%; top:20px;">
          <!-- <br /><img src="static/styles/Secure.png" width="150px"
height="150px" alt="logo"><br /> -->
          <br /><img src="Secure.png" width="150px" height="150px"
alt="logo"><br />
        </div>
        <h2 class="mt-12 text-center font-semibold text-xl mb-5">
          Get Started!
        </h2>
        <table class="w-full mb-16">
          <tr class="flex justify-center">
            <td>
              <a href="upload"><button
```

```
51                  class="py-2 px-4 border transform duration-200 hover:text-
   black hover:bg-gray-100 hover:-translate-y-1">
52                  Upload
53                </button></a>
54              </td>
55              <td>
56                <a href="download"><button
57                  class="py-2 px-4 border transform duration-200 text-black
   hover:text-white hover:bg-transparent bg-gray-100 hover:-translate-y-1 ml-10">
58                  Restore
59                </button></a>
60              </td>
61            </tr>
62          </table>
63          <br />
64          <div class="flex-col text-sm mx-auto text-center">
65            <h5>© 2024 Ashish Kumar Thyadi,G.Sravani Vaishali,P.jyothika &
   CH.Surya Sagar. All rights reserved</h5>
66          </div>
67        </div>
68      </div>
69  </body>
70
71  </html>
```

71.1 APPENDIX – II SNAPSHOTS





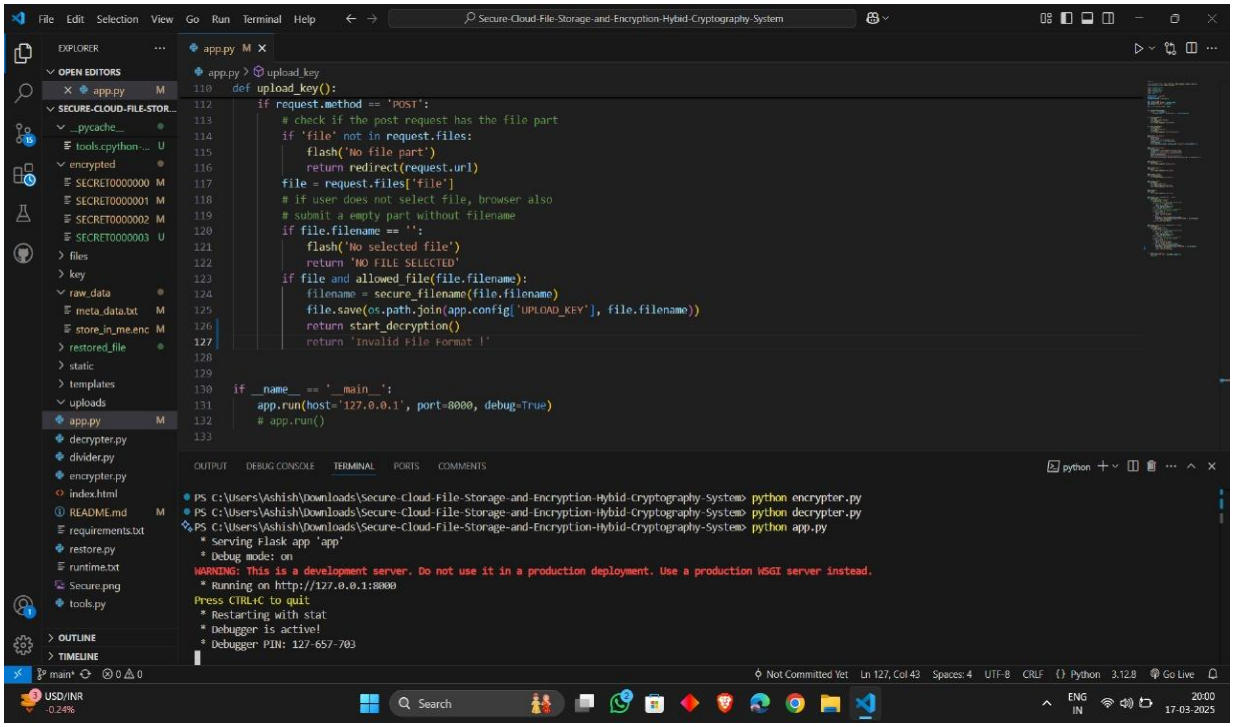


FIGURE 4.1 SAMPLE CODE

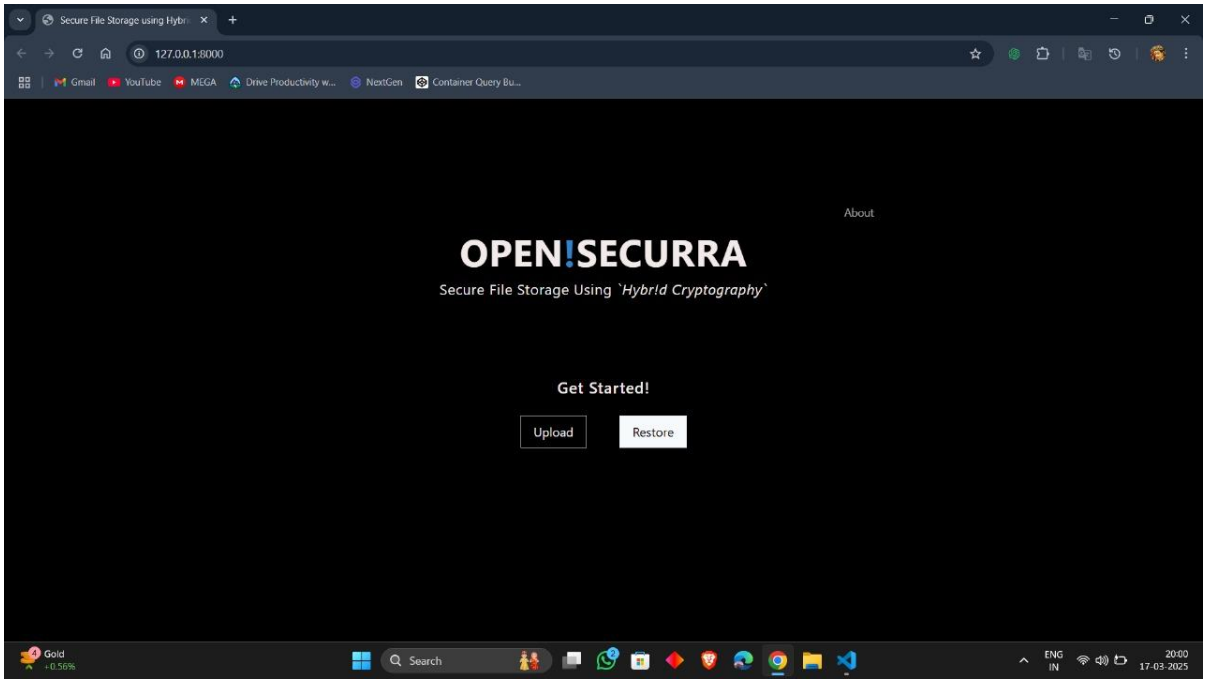


FIGURE 4.2 APPLICATION HOME PAGE

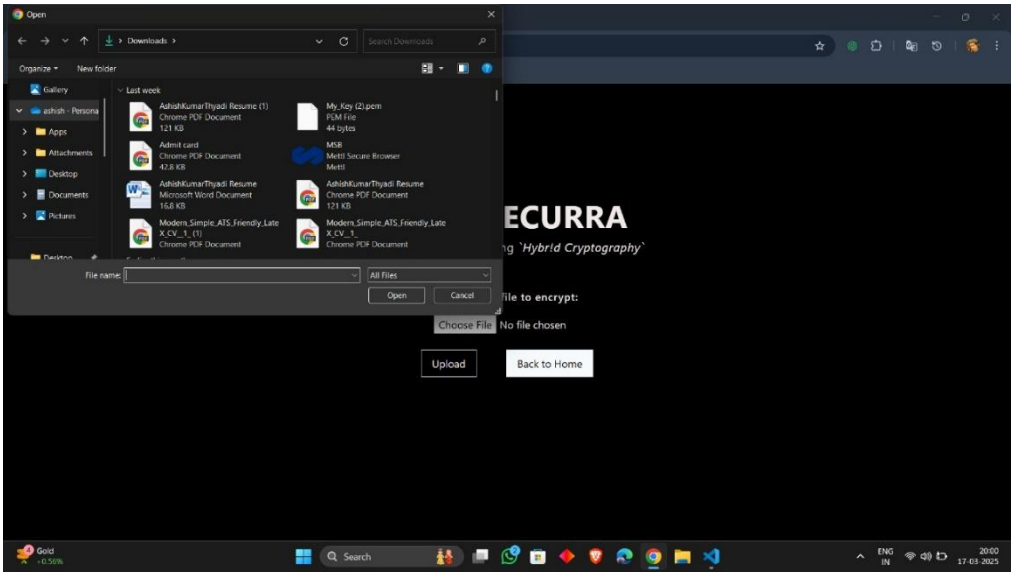
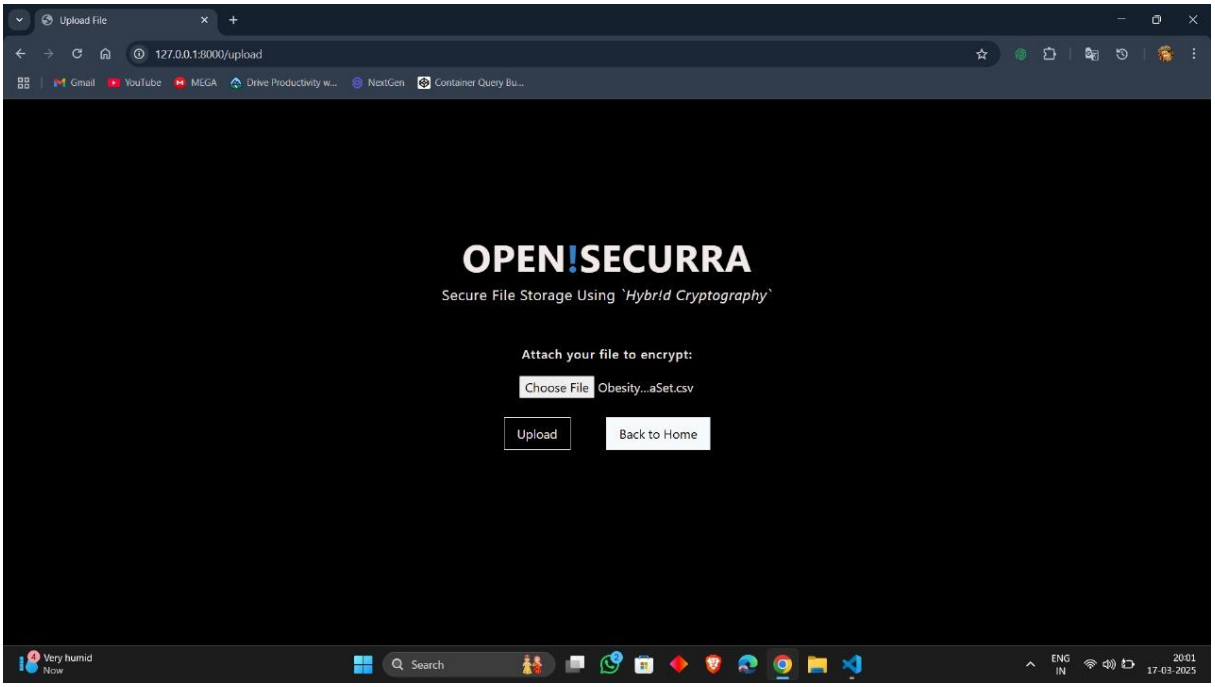


FIGURE 4. FILE UPLOAD PROCESS



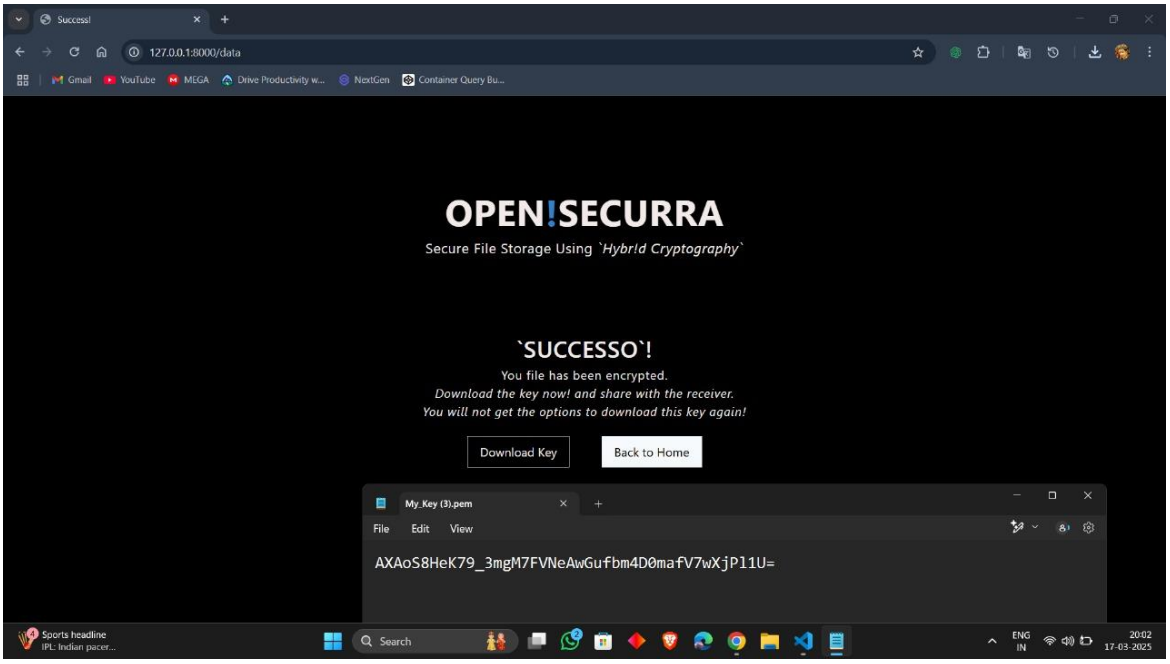
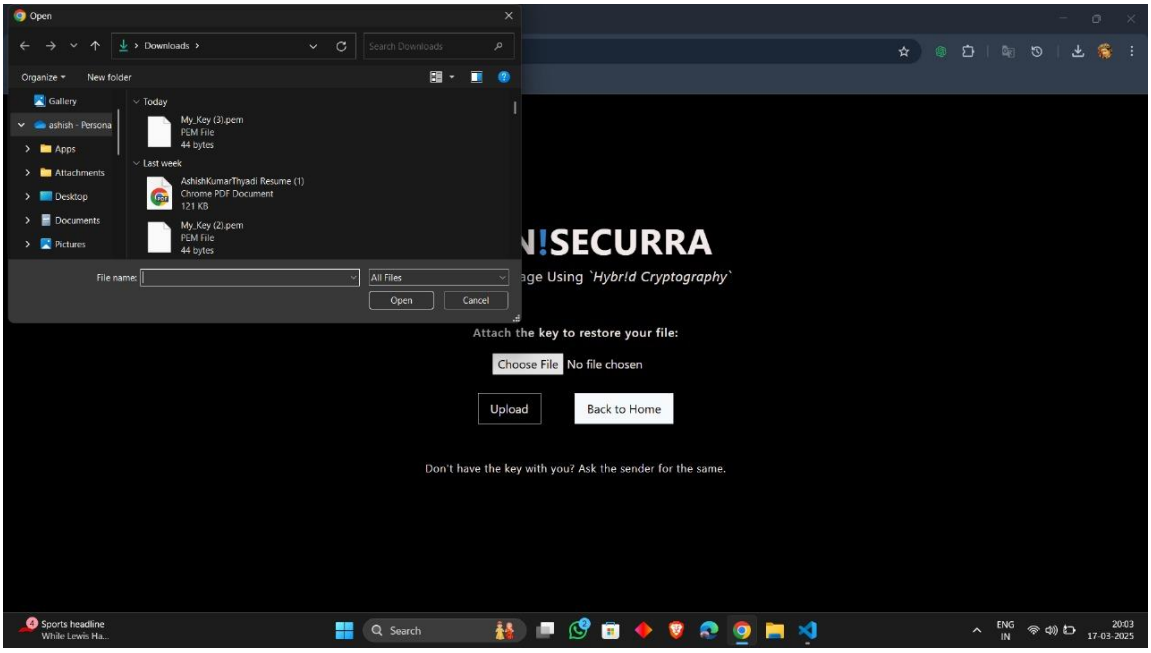
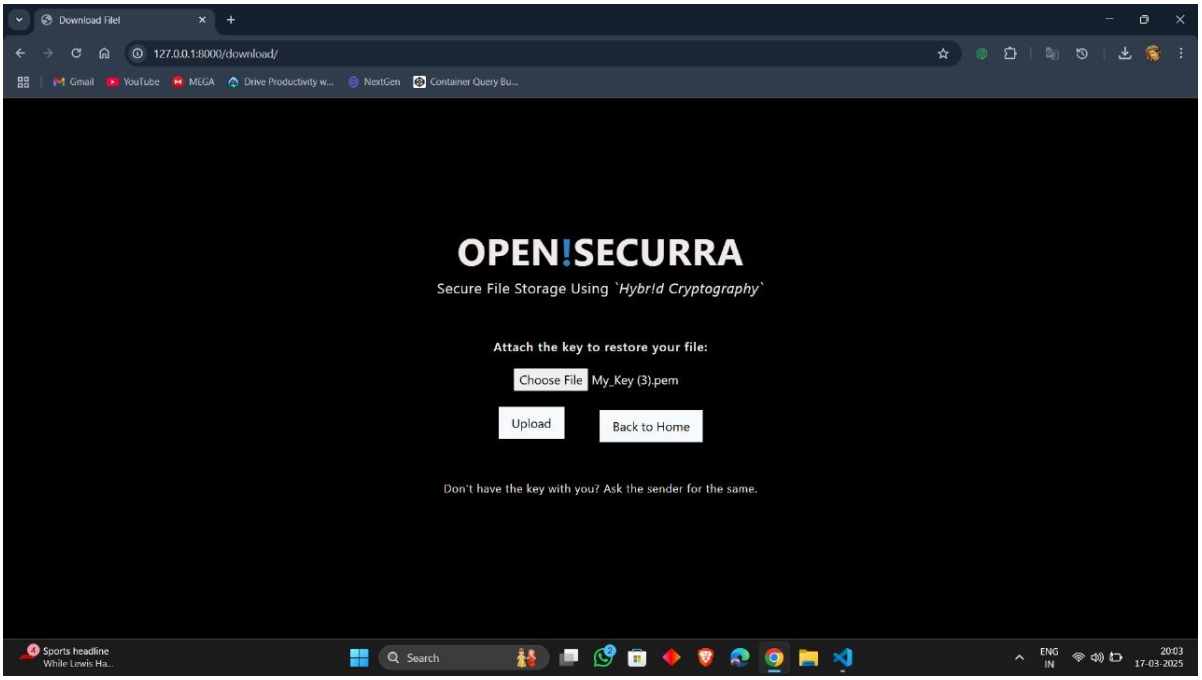


FIGURE 4.4 ENCRYPTION EXECUTION





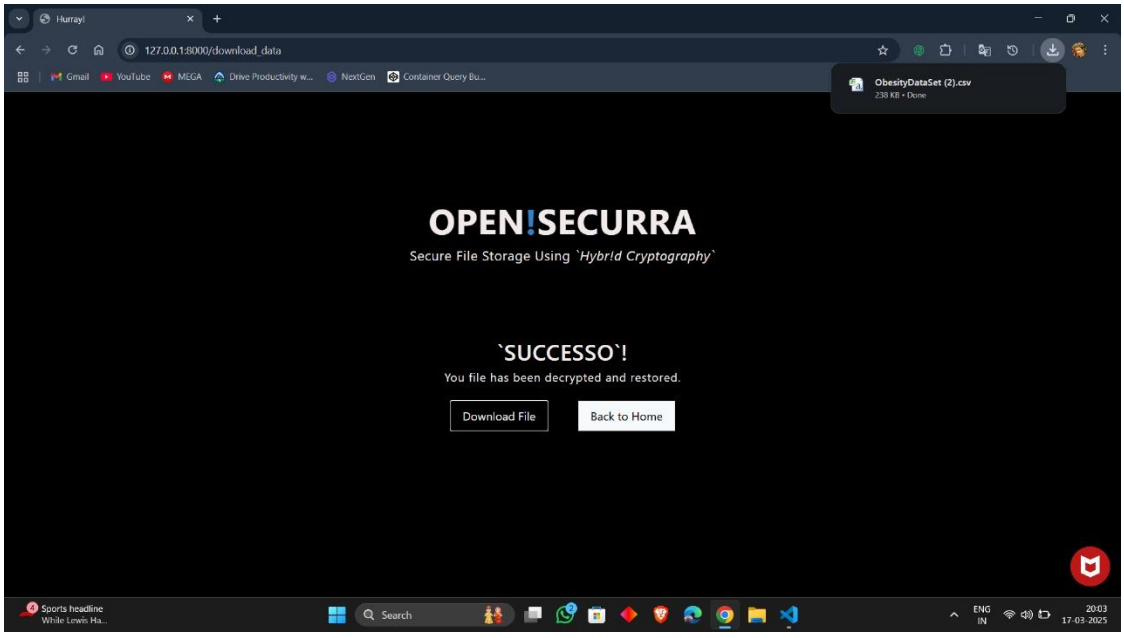


FIGURE 4.5 DECRYPTION EXECUTION

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"SECURE FILE STORAGE USING HYBRID CRYPTOGRAPHY"

[1]K.T.Krishna Kumar, [2] G. Sravani Vaishali, [3]Ashish Kumar Thyadi, [4]P.Jyothika,[5]CH. Surya Sagar

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Abstract : Data security is a critical concern in modern digital systems, especially for cloud storage solutions. This project, Secure File Storage Using Hybrid Cryptography, implements a robust encryption mechanism to ensure the confidentiality, integrity, and authenticity of stored files. By combining symmetric and asymmetric encryption techniques, such as AES, RSA, ChaCha20-Poly1305, AES-GCM, and AES-CCM, the system provides strong security while maintaining efficiency. The project features file chunking for optimized processing, secure key management, and flexible encryption modes, making it scalable and adaptable for various use cases. Performance tests demonstrate high-speed encryption and decryption, making this system a practical solution for secure file storage in cloud environments.

IndexTerms **- , Hybrid Cryptography, AES, RSA, ChaCha20-Poly1305, AES-GCM, AES-CCM, Secure Key Management, File Chunking, Multi-Layer Security**

1.Introduction

A significant issue in today's digital world, with cloud storage, is the non-data security environment. As people depend more on the cloud, however, how to deliver information that is secure everywhere and will not be changed or corrupted if it gets lost becomes ever more pressing. Various traditional cryptographic methods but two of the most successful ones are AES (Advanced Encryption Standard), i.e., DES (Data Encryption Algorithm). And RSA (Rivest-Shamir-Adleman) has been widely used for secure storage of data. [1] Using only one method of encryption can expose problems in multiple places, especially if someone manages to obtain access to the encryption keys. This calls for a more robust security regime for cloud computing. [2].

To address the challenges posed by these concerns, the current research works with a novel file storage model that integrates hybrid cryptography. This model works by combining symmetric and asymmetric encryption methods, including AES, RSA, ChaCha20-Poly1305, AES-GCM, and AES-CCM, to enhance data security without reducing operational efficiency [3]. Through the implementation of a file chunking approach, encryption is performed on smaller data chunks, thus maximizing processing speed and reducing computational requirements [4]. In addition, proper key management lends support to robust protection against unauthorized access [5]. Performance tests demonstrate the effectiveness of the system in providing high-speed encryption and decryption, making it a best-fit solution for secure cloud storage [6].

2. Existing System

Modern cloud security models largely use a single encryption method; say AES and RSA [7]. The methods might be efficient but have no dearth of disadvantages. When a single encryption key is breached through a hack, there is a sole point of failure that jeopardizes the entire database [8]. Asymmetric encryption algorithms such as RSA are computationally intensive, thus preventing large amounts of data encryption [9]. Traditional encryption models have no adaptive security models to counter the dynamic nature of cyber-attacks [10]. Stored keys used for encryption in the cloud platforms also become priority targets for cyber-attacks, thus introducing the vulnerabilities related to key management [11]. These are major reasons for using a hybrid approach using different cryptologic methods that target minimizing threats while enhancing security [12].

2.1 Limitations of the Existing System

- Single Point of Failure: The entire database is at risk if the encryption key is compromised.
- High Computational Needs: RSA and other asymmetric encryption algorithms are very computationally intensive, which makes them unusable for large data encryption.

- ❖ Lack of Adaptability: Legacy encryption schemes fail to dynamically respond to changing cyber threats.
- ❖ Key Management Risks: Storage of encryption keys in the cloud heightens their exposure to attack.
- ❖ Lack of Redundancy: When one encryption method fails, there is no other form of security that can offset the resulting risk.

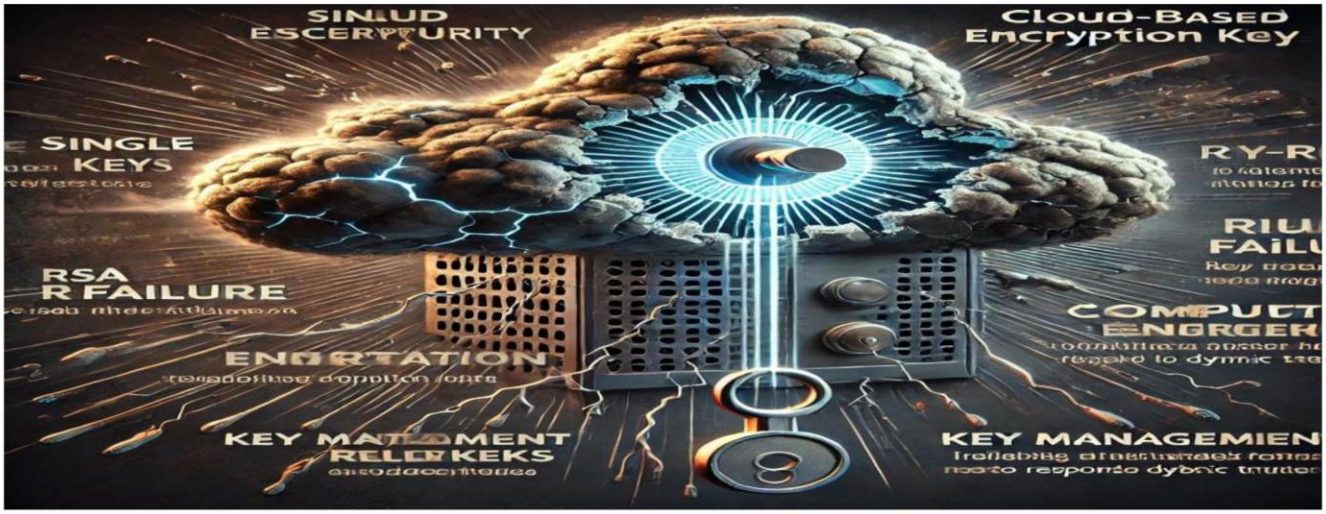

Fig.1.limitations of modern cloud security models.

3. Proposed System

The proposed system employs hybrid cryptographic mechanisms, which incorporate AES, RSA, and ChaCha20-Poly1305, AES-GCM, and AES-CCM encryption techniques [19]. Use of file chunking improves encryption and decryption performance, allowing for fast processing without compromising security integrity [20]. Use of different modes of encryption improves security redundancy, thus minimizing key compromise risk and improving data protection [21]. Secure key management protocol guarantees that the encryption keys can never be accessed without authorization and, hence, the risk of security attack is eliminated [22]. Moreover, scalability in cloud security is guaranteed through fast processing mechanisms that provide low latency and uniform retrieval of data [23].

Fig.2.visualization of the hybrid cryptographic security system

3.1 Advantages of the Proposed System

- ❖ Hybrid Cryptography: Employs AES for local high-speed block file encryption, RSA for secure key exchange, and other algorithms (ChaCha20-Poly1305, AES-GCM, and AES-CCM) for multi-layer encryption.
- ❖ File Chunking: Encrypting in smaller data chunks enhances processing performance and minimizes computational overhead.

- Secure Key Management: Safeguarding the encryption keys by storing them securely and keeping them away from unauthorized access.
- Security Redundancy: Even if a single encryption technique is cracked, others remain that prevent full data exposure.
- Enhanced Efficiency: Techniques for faster processing guarantee lesser lag and consistent data gathering.
- Scalability and Adaptability: Cloud storage, secure file sharing, and high-security applications.
- Data Integrity Verification: Data integrity checking uses hashing methods to detect unauthorized changes and maintain data integrity.

4. Methodology

4.1. Research Approach

Mixed-methods design was used, including literature reviews, experimental testing, and performance measures.

4.2. Encryption Process

Files are split, and all of them are encrypted with AES, RSA, ChaCha20-Poly1305, AES-GCM, and AES-CCM.

4.3. Decryption & Data Retrieval

Encrypted data segments are retrieved from cloud storage and subsequently decrypted according to the respective cryptographic procedures.

4.4. Performance & Security Testing

The system was subjected to penetration testing and attack simulations to test how resistant the system is to unauthorized access.

4.5. Ethical Considerations

The program follows stringent security and privacy practices to ensure adherence to generally accepted industry norms.

Applications

This system has practical applications in various domains requiring high-security cloud storage solutions [6].

- **Finance:** Protects financial records and transaction data.
- **Healthcare:** Ensures patient confidentiality and regulatory compliance (HIPAA, GDPR).
- **Government & Defence:** Safeguards classified information from cyber threats.
- **Enterprise Security:** Provides secure cloud storage, preventing data breaches.

Challenges and Future Directions

Challenges

Computational Complexity and Performance Overhead

The employment of several encryption algorithms significantly increases computational hardness and demands more processing power than individual encryption methods [11].

Greater Storage Needs

Division of data into multiple segments for encryption increases file sizes relative to the standard single-encryption method [12].

Key Management Complexity

Proper handling and secure storage of encryption keys are essential to avoid unauthorized access [13].

Cloud Security Issues

even when encrypting data before storage in the cloud, threats such as malicious insiders and quantum attacks remain significant [14].

Issues regarding Compatibility and Integration

The use of hybrid encryption on multiple platforms may involve changes to current cloud infrastructures [16].

Future Directions

- Use of Lightweight Cryptography to minimize computational overhead while providing robust security [16].
- Utilizing blockchain technology to manage keys, secure storage, and key distribution is ensured to be secure [17].
- Adopt safe cryptographic techniques that are quantum-computing-proof [18].
- AI-Driven Security Features for real-time anomaly detection and cyber threat prevention [19].
- Increased Cloud Security Policies supporting zero-trust models and end-to-end encryption [20].

Conclusion

This research proposes a hybrid cryptographic approach for secure file storage in cloud environments. Through the use of AES, RSA, ChaCha20-Poly1306, AES-GCM, and AES-CCM, combined with file chunking and good key management practices, the new system greatly enhances data security, confidentiality, and system performance [20]. Performance tests confirm its efficiency as an end-to-end cloud security solution, with better performance compared to traditional encryption methods. Quantum-resistant cryptographic techniques and block chain-based key management will be explored in future research [21].

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