# MITIGATING CYBER THREATS WITH NEXT- GEN AUTHENTICATION

**PROJECT REPORT**

***Submitted by***


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*In partial fulfilment for the award of the degree*
*Of*

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**ANNA UNIVERSITY, CHENNAI.**

*Under the supervision and guidance*
*Of*


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**KIT -KALAIGNARKARUNANIDHI INSTITUTE OF TECHNOLOGY**

**An Autonomous Institution**

**Accredited with 'A' Grade by NAAC & NBA**

**COIMBATORE-641402**


**MAY- 2025**

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**DEPARTMENT OF COMPUTER APPLICATIONS**

**M23CAP401- PROJECT WORK**

This is to certify that the project work entitled

# MITIGATING CYBER THREATS WITH NEXT- GEN AUTHENTICATION

Is the bonafide record of project work done by

**THARUNYA AMIRTHAM S**

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**MASTER OF COMPUTER APPLICATIONS**

During the year

2024-2025

**Project Guide** **Head of the Department**

Submitted for the Project Viva – Voce examination held on _____.

Internal Examiner External Examiner

# DECLARATION

I affirm that the project work titled **"MITIGATING CYBER THREADS WITH NEXT-GEN AUTHENTICATION"** is the original work Of **Ms. S. THARUNYA AMIRTHAM (Reg.No.711523MMC057)** being submitted in partial fulfilment for the award of **MASTER OF COMPUTER APPLICATIONS**. Certified further, that to the best of my knowledge the work reported here in does not form part of any other project report or dissertation work submitted for award of any degree or diploma, either in this or any other university on earlier occasion by me or any other candidates.

**THARUNYA AMIRTHAM S**
**Reg.No.711523MMC057**

I certify that the declaration made above by the candidate is true, to my knowledge.

**Signature of the Guide**
**Mr. R. PUNITHAVEL MCA., (Ph.D).,**
**Assistant Professor (Sr.G) & Project Guide,**
**Department of Computer Applications**

# ABSTRACT

# ABSTRACT

Many security primitives are based on hard mathematical problems. Using hard AI problems for security is emerging as an exciting new paradigm but has been underexplored. In this project, I present a new security primitive based on hard AI problems, namely, a novel family of graphical password systems built on top of Captcha technology, which we refer to as **Next-Gen Authentication using Captcha-based Graphical Passwords**. This system enhances security by addressing multiple threats, such as online guessing attacks, relay attacks, and, if combined with dual-view technologies, shoulder-surfing attacks. Notably, passwords in this system can only be found probabilistically by automatic online guessing attacks, even if they exist in a search set. Additionally, this approach mitigates the well-known image hotspot problem in traditional graphical password systems, such as Pass Points, which often lead to weak password choices.

To enhance the system's functionality, this project is integrated a **secure file storage module** after the login process. This module allows authenticated users to securely store, retrieve, and manage their files within the system. By leveraging encryption and access control mechanisms, the file storage system ensures the confidentiality and integrity of stored data. This additional feature strengthens security by not only protecting user authentication credentials but also safeguarding sensitive files. While not a universal solution, this next-generation authentication system offers a practical balance between security and usability. It is well-suited for real-world applications where enhanced authentication and secure file management are essential for mitigating cyber threats.

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# ACKNOWLEDGEMENT

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# INTRODUCTION

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# INTRODUCTION

## 1.1 ABOUT THE PROJECT

In the modern digital era, authentication plays a crucial role in ensuring the security of online systems. Traditional password-based authentication methods suffer from various vulnerabilities, including brute-force attacks, phishing, and shoulder surfing. To address these security challenges, next-generation authentication mechanisms have emerged as a promising alternative, leveraging advanced security techniques to enhance user protection. This project, "Mitigating Cyber Threats with Next-Gen Authentication," introduces an innovative authentication scheme that combines the strengths of Captcha and graphical passwords. This approach enhances security by making it computationally challenging for automated attacks to guess passwords while maintaining user-friendly authentication. Unlike conventional graphical password systems, which are prone to image hotspot issues leading to predictable passwords, this system dynamically generates images for authentication, ensuring a higher level of security.

Beyond authentication, this project also integrates a secure file storage system, providing users with a safe environment to store and manage their sensitive data after successful login. The file storage module employs encryption and access control mechanisms to prevent unauthorized access, ensuring data confidentiality and integrity. By combining advanced authentication techniques with secure file storage, this system offers a comprehensive solution for mitigating cyber threats and addressing common authentication vulnerabilities. The project is designed to be scalable and adaptable for real-world applications, making it a viable security enhancement for various platforms requiring secure authentication and data management.

# SYSTEM ANALYSIS

# CHAPTER 2
# SYSTEM ANALYSIS

## 2.1 EXISTING SYSTEM

Traditional authentication methods primarily rely on text-based passwords, which are highly vulnerable to brute-force attacks, dictionary attacks, phishing, and keylogging. To enhance security, CAPTCHA-based authentication is used to differentiate human users from bots, but it often leads to usability issues such as accessibility challenges and user frustration. Another alternative, graphical password authentication, leverages images or patterns for login, offering improved memorability. However, graphical passwords are still susceptible to image hotspot problems, shoulder-surfing attacks, and online guessing attacks, making them less secure in certain scenarios. These limitations highlight the need for a more robust authentication system that addresses security concerns while maintaining user convenience.

### 2.1.1 DISADVANTAGES

- **Hotspot Issue (Predictable Passwords):** Users tend to select predictable areas in images, making graphical passwords vulnerable to pattern analysis and heatmap attacks, allowing attackers to guess passwords easily**.**
- **Brute Force and Guessing Attacks:** Despite offering a larger password space, graphical passwords can still be cracked using machine learning algorithms and automated pattern recognition techniques**.**
- **Shoulder Surfing Attacks:** Attackers can observe and replicate user interactions, such as image selections or drawn patterns, making graphical passwords insecure in public environments**.**
- **Slow Authentication Process:** Compared to traditional text-based passwords, graphical authentication methods require **more time for selection**, leading to usability concerns in **fast-paced environments.**

## 2.2 PROPOSED SYSTEM

The proposed system introduces a next-generation authentication mechanism that enhances security by integrating Captcha-based graphical passwords. Traditional authentication methods, such as text-based passwords, are highly vulnerable to brute-force attacks, dictionary attacks, phishing, and keylogging. Graphical password systems, while offering better memorability, often suffer from hotspot vulnerabilities, where users select predictable areas within an image, making them easier to guess.

To overcome these challenges, the proposed system leverages dynamic image generation to ensure that each authentication session presents a unique challenge. Instead of relying on static images, which can be studied and exploited by attackers, this system generates new Captcha images for every login attempt, making passwords non-repetitive and unpredictable. This effectively eliminates brute-force attacks and hotspot issues.

Additionally, the system reduces shoulder-surfing risks by constantly changing authentication elements, preventing attackers from replicating a user's login pattern. Unlike traditional Captcha mechanisms, which often frustrate users, this system seamlessly integrates Captcha technology with graphical passwords, ensuring both security and usability. Users do not need to memorize complex alphanumeric passwords, making the authentication process more user-friendly while maintaining strong resistance against cyber threats.

### 2.2.1 ADVANTAGES OF PROPOSED SYSTEM

- **Dynamic Image Generation:** The system generates a new image for each login attempt, preventing attackers from analyzing hotspots or predicting password patterns. This ensures unique authentication sessions and enhances resistance to pattern-based attacks.

- **Enhanced Security Against Cyber Threats:** Dynamic images prevent brute-force attacks, while random selection eliminates hotspots, making password prediction difficult. Dual-view technology and changing images reduce shoulder-surfing risks, enhancing overall security**.**
- **Captcha-Integrated Authentication:** Users authenticate by selecting a sequence of graphical elements from AI-resistant Captcha images, making the system secure against brute-force attacks.
- **Enhanced User Experience and Usability:** The system balances security and usability, removing the need for complex passwords. The Captcha-based authentication is intuitive and user-friendly, ensuring strong security without compromising convenience.

## 2.3 FEASIBILITY STUDY

The feasibility study evaluates the viability of the proposed authentication system, ensuring its practicality, efficiency, and security before development begins. This study serves as the first critical step in the software development lifecycle, laying a strong foundation for subsequent design and implementation phases. By systematically analyzing various aspects of the system, the feasibility study helps identify potential challenges, assess opportunities, and determine the strategic direction for successful deployment.

The study involves a detailed examination of the system’s functionality, focusing on its ability to enhance security, usability, and resistance to cyber threats. It assesses whether the system aligns with user needs and its potential impact on improving authentication security. Key factors such as technical feasibility, economic viability, and operational effectiveness are analyzed to ensure a balanced evaluation. The findings of this study are compiled into a comprehensive report, offering clear recommendations on whether to proceed with the engineering and development process. This report serves as a decision-making tool for stakeholders, weighing the system’s feasibility, benefits, and risks.

### 2.3.1 ECONOMIC FEASIBILITY

The economic feasibility analysis assesses whether the proposed authentication system is a cost-effective solution and a worthy investment for implementation. This evaluation considers the financial implications of developing, deploying, and maintaining the system, ensuring that the benefits significantly outweigh the costs. The goal is to confirm that the system provides substantial value in terms of enhanced security, improved efficiency, and reduced cyber threats, justifying the overall investment.

The system is open-source, meaning it is freely accessible to users without requiring licensing fees. This eliminates one of the most significant expenses associated with proprietary software, reducing the financial barrier for organizations. Additionally, the system operates as a self-contained standalone application, requiring no additional software or infrastructure investments. This further minimizes costs by eliminating dependencies on external processing tools.

By providing a highly secure and efficient authentication mechanism at no additional cost, the system ensures economic viability while maintaining a low total cost of ownership. Its cost-effectiveness and ease of deployment make it an attractive option for organizations seeking secure, scalable, and budget-friendly authentication solutions.

### 2.3.2 OPERATIONAL FEASIBILITY

Operational feasibility evaluates whether the proposed authentication system will function effectively and efficiently in its intended environment once deployed. It ensures that the system meets technical requirements while also aligning with user needs and real-world conditions. Understanding the daily operational environment and potential challenges helps ensure smooth implementation and usability.

The validation process involves customizing the system to meet user expectations by actively engaging with users during development. Feedback loops are established to identify potential issues and refine system functionalities, ensuring that the final product is intuitive, user-friendly, and efficient. A user-centered approach helps minimize operational difficulties and enhances overall satisfaction.

Assessing user technical capabilities is crucial for a smooth transition. Training programs and support systems are implemented to equip users with necessary skills, reducing learning curves and ensuring efficient system adoption. By addressing usability, training, and practical integration, operational feasibility ensures that the system seamlessly integrates into daily operations, providing enhanced security and a streamlined user experience without disrupting existing workflows.

### 2.3.3 TECHNICAL FEASIBILITY

Technical feasibility is a crucial component of the feasibility study, evaluating all technological aspects necessary for the successful implementation and sustainability of the authentication system. This assessment ensures that the system functions reliably, maintaining consistent performance without failure. It also examines the suitability and availability of required technologies, ensuring that the necessary tools, frameworks, and platforms are accessible for development.

A key focus is on performance analysis, which assesses the system’s speed, efficiency, and ability to handle user demands. Scalability is evaluated to ensure the system can accommodate increasing users without compromising performance. Additionally, maintainability is analyzed to determine how easily the system can be updated, managed, and improved over time. By conducting a comprehensive technical assessment, potential risks and challenges are identified early, allowing for proactive solutions. This ensures that the system is robust, adaptable, and capable of delivering a secure and seamless authentication experience, laying a strong foundation for long-term success.

# SYSTEM SPECIFICATION

# CHAPTER 3

# SYSTEM SPECIFICATION

## 3.1 HARDWARE REQUIREMENTS

- PROCESSOR : Inter Core i5 or Higher
- RAM : Minimum 8 GB
- STORAGE : Minimum 16 GB HDD/SSD

## 3.2 SOFTWARE REQUIREMENTS

- FRONT END : React.js
- BACK END : Node.js, Express.js
- DATABASE : MongoDB

# SOFTWARE DESCRIPTION

# CHAPTER 4

# SOFTWARE DESCRIPTION

## 4.1 FRONT END

### 4.1.1 React.js

In the realm of modern web development, React.js is an open-source JavaScript library used for building user interfaces, primarily for single-page applications. Developed and maintained by Meta (formerly Facebook), React allows developers to build web applications that can update and render efficiently in response to data changes. A person working with React.js may be referred to as a React Developer or a Frontend Developer. React enables the creation of reusable UI components, making it an essential tool in today's dynamic, data-driven web environments.

React.js is not a full-fledged framework but rather a library focused on the view layer of an application, aligning with the Model-View-Controller (MVC) architecture. It uses a declarative style of programming, allowing developers to describe what the UI should look like for a given state, and React takes care of updating the UI efficiently when the state changes.

React.js is used in a variety of sectors, including e-commerce, education, finance, healthcare, entertainment, and more. It powers interactive interfaces in social networks, dashboards, portals, and media platforms. Many popular companies such as Instagram, Airbnb, Netflix, and Uber use React in production.

**Component-Based Architecture**

React applications are built using components, which are self-contained, reusable pieces of code that define how a portion of the UI should appear and behave. This modular approach increases development efficiency and maintainability, allowing developers to isolate and reuse code across projects.

**JSX (JavaScript XML)**

React uses JSX, a syntax extension that allows HTML to be written within JavaScript. This makes the code more readable and easier to write, as developers can visually see the component structure while also incorporating logic and dynamic behavior directly.

**Virtual DOM**

React uses a Virtual DOM to optimize rendering performance. When a component's state changes, React calculates the difference between the previous and current Virtual DOM and updates only the parts of the real DOM that have changed, ensuring fast and efficient updates.

**State and Props**

React manages data through state (data owned by a component) and props (data passed between components). This system allows for dynamic, interactive user interfaces that respond to user input and real-time data.

**Hooks and Functional Components**

With the introduction of Hooks (like useState, useEffect), React supports writing components as pure JavaScript functions, moving away from class-based components. Hooks enable developers to use state and lifecycle features without writing a class.

**React Ecosystem and Tooling**

React has a rich ecosystem including tools like React Router for navigation, Redux for state management, and Next.js for server-side rendering and static site generation. These tools extend React's functionality for building scalable, performant applications.

**User Interface and Experience**

React promotes the creation of responsive and dynamic interfaces that adapt to user interaction and data changes in real time. Combined with CSS frameworks or component libraries like Material UI or Tailwind CSS, React enhances the user experience across devices and screen sizes.

## 4.2 BACK END

### 4.2.1 Node.js

Node.js is an open-source, cross-platform runtime environment that allows developers to execute JavaScript code outside of a web browser. It is built on Chrome's V8 JavaScript engine and is designed to build scalable and high-performance applications, especially web servers and networking tools. Node.js uses an event-driven, non-blocking I/O model, making it lightweight and efficient for real-time applications. Developers who work with Node.js are often referred to as backend developers or full-stack developers.

**Asynchronous and Event-Driven Architecture**

Node.js operates on a non-blocking I/O model, allowing it to handle multiple operations concurrently. This makes it particularly well-suited for applications that require real-time data processing, such as chat applications, online gaming platforms, or collaborative tools.

**JavaScript Everywhere**

One of the key advantages of Node.js is that it enables developers to use JavaScript on both the client-side and server-side. This unification simplifies development workflows, improves code reusability, and streamlines team collaboration.

**NPM (Node Package Manager)**

Node.js comes bundled with NPM, the world's largest software registry. NPM provides access to thousands of reusable packages and libraries that significantly speed up development and reduce redundant coding.

**Backend Development with Express.js**

While Node.js provides the runtime, Express.js is a minimal and flexible web application framework that runs on top of Node.js. It simplifies the development of APIs and server-side applications by providing robust features for routing, middleware integration, and more.

**Use in Modern Applications**

Node.js is used extensively in modern application development across various industries. It powers streaming services, RESTful APIs, IoT platforms, and even serverless architecture with frameworks like AWS Lambda and Google Cloud Functions. It's also a key component in full-stack JavaScript environments such as the MERN stack.

**Real-Time Communication**

Thanks to libraries like Socket.IO, Node.js excels at enabling real-time communication between clients and servers. This makes it ideal for use cases like multiplayer games, live chat systems, and collaborative platforms like Google Docs.

**Community and Ecosystem**

Node.js boasts a large and active community of developers who continuously contribute to its ecosystem. This results in frequent updates, a rich selection of plugins, and strong community support.

**Scalability**

The event loop allows Node.js to handle thousands of connections simultaneously with minimal resource consumption. The single-threaded model, combined with asynchronous I/O operations, enables developers to build highly scalable applications.

**Fast Performance**

Node.js is built on the V8 JavaScript engine, which is known for its high performance. V8 compiles JavaScript directly to machine code, making execution extremely fast.

**Single-Threaded but Highly Scalable**

Node.js operates on a single-threaded event loop. Unlike traditional servers that spawn multiple threads to handle concurrent connections, Node.js uses a single thread to handle all requests. This approach minimizes overhead and improves performance.

**Microservices and APIs**

Node.js is well-suited for developing microservices and APIs due to its lightweight and efficient nature. Microservices architectures benefit from Node.js's ability to handle many small services that communicate with each other seamlessly.

### 4.2.2 Express.js

Express.js is a fast, minimalist, and flexible web application framework for Node.js, designed to simplify the development of robust APIs and web applications. It provides a lightweight structure to build server-side applications while allowing full control over request and response handling. Express.js is widely adopted for its scalability, ease of use, and integration with the broader Node.js ecosystem.

**Routing and Middleware**

One of the core strengths of Express.js is its powerful routing system and support for middleware. Routing allows developers to define application endpoints and handle HTTP methods such as GET, POST, PUT, and DELETE. Middleware functions, which are central to Express architecture, enable preprocessing of requests and responses, including authentication, logging, and error handling.

**RESTful API Development**

Express.js is commonly used for building RESTful APIs due to its simplicity and flexibility. Developers can define API endpoints and control the logic for data retrieval, storage, and manipulation. Its modular structure makes it easy to separate routes and controller logic, supporting clean code organization.

**Templating and Static Files**

Express.js supports a variety of templating engines like EJS, Pug, and Handlebars for dynamic content rendering. It also allows the serving of static assets such as images, stylesheets, and client-side JavaScript from a designated directory, facilitating full-stack development within a single framework.

**Integration with Databases**

Express.js easily integrates with both SQL and NoSQL databases through packages like Sequelize (for PostgreSQL or MySQL) and Mongoose (for MongoDB). This enables developers to build complete data-driven applications, from frontend requests to backend processing and data storage.

**Development and Debugging Tools**

With built-in error handling and support for popular debugging tools, Express.js enhances the developer experience. Tools like nodemon automatically restart the server upon file changes, while middleware like morgan provides HTTP request logging for debugging and monitoring.

**Scalability and Extensibility**

Express.js applications can be scaled horizontally and vertically with ease. It supports modular application structures and can be extended using third-party packages from the npm ecosystem. From handling sessions to enabling security features like CORS and rate limiting, Express provides the flexibility needed for enterprise-grade applications.

**Use Cases**

Express.js is used in a wide variety of applications — from developing APIs for mobile apps to powering full-scale web applications and microservices architectures. It is widely used in tech startups, large enterprises, and educational platforms due to its simplicity and versatility.

**Faster Server-Side Development**

Express.JS includes a large number of commonly used features present in Node.JS in the form of functions. These functions can be readily employed for specific roles anywhere in the program. This step removes the need to code for several hours for common roles, and thus helps a business save precious time when developing an app. Time to market is an essence for any business and reducing time spent in coding can go a long way in allowing businesses to launch their product faster.

**Middleware**

Middleware is a part of the program that has access to the database, client request, and the other forms of middleware. It plays a huge role in management of functions of the app. It is mainly responsible for the systematic organization of different functions of Express.JS.

## 4.3 DATABASE

### 4.3.1 MongoDB

MongoDB is a powerful, open-source NoSQL database management system that stores data in a flexible, JSON-like format called BSON (Binary JSON). Instead of traditional table-based relational database structures, MongoDB uses collections and documents, making it ideal for handling unstructured or semi-structured data. This design allows for faster development, easier scalability, and more intuitive data representation in modern applications. MongoDB is often used in big data, real-time analytics, content management, mobile applications, and IoT systems. A developer who works with MongoDB is often called a MongoDB Developer or NoSQL Database Engineer.

**Document-Oriented Storage**

MongoDB stores data in documents rather than rows and columns. Each document is a set of key-value pairs, similar to JSON objects. This allows for rich, nested data structures and makes MongoDB ideal for applications where data can vary in structure.

**Schema Flexibility**

Unlike traditional relational databases, MongoDB does not require a fixed schema. This flexibility allows developers to iterate faster and accommodate changes in data models without costly migrations or downtime.

**High Performance and Scalability**

MongoDB supports horizontal scaling via sharding, which distributes data across multiple machines. This enables it to handle large volumes of data and high-throughput operations, making it suitable for enterprise-scale applications and real-time analytics.

**Integration with Web Technologies**

MongoDB integrates well with modern web development frameworks and languages such as Node.js, Python, and Java. It is often used in full-stack development with the MERN or MEAN stacks.

**Aggregation and Query Capabilities**

MongoDB provides a powerful aggregation framework that allows for data transformation and analytics within the database itself. Complex queries, filters, and pipelines can be executed efficiently to derive insights from the data.

**Security and Access Control**

MongoDB offers robust security features including authentication, authorization, encryption, and auditing. Role-based access control and network-level security ensure data is protected in multi-user environments.

**Cloud and Atlas Integration**

MongoDB Atlas is a fully managed cloud version of MongoDB that automates infrastructure, backups, scaling, and monitoring. It simplifies deployment and allows developers to focus on building applications without worrying about backend maintenance.

**Indexing**

In MongoDB database, every field in the documents is indexed with primary and secondary indices this makes easier and takes less time to get or search data from the pool of the data. If the data is not indexed, then database search each document with the specified query which takes lots of time and not so efficient.

**Replication**

MongoDB provides high availability and redundancy with the help of replication, it creates multiple copies of the data and sends these copies to a different server so that if one server fails, then the data is retrieved from another server.

**Load balancing**

Proper load balancing is fundamental to database management for expansion in large-scale organizations. As client traffic and requests come in thousands and millions, they must be well distributed across the different servers to maximize performance and reduce over congestion.

# PROJECT DESCRIPTION

# CHAPTER 5
# PROJECT DESCRIPTION

## 5.1 MODULES

- Visual Password Registration Module
- Data Authentication Module
- Attack guessing Module
- Captcha Security Module
- KeyGen Module
- Secure File Storage Module

### 5.1.1 VISUAL PASSWORD REGISTRATION MODULE

The Visual Password Registration Module serves as the primary gateway for user authentication, enabling users to create secure graphical passwords by interacting with Captcha-generated images. Unlike traditional alphanumeric passwords, which are susceptible to brute-force attacks, this module employs a graphical approach where users select specific regions, patterns, or sequences within an image to form their password. These interactions are securely mapped and stored for subsequent login verification. The module enhances security by increasing the complexity of password guessing and mitigates the image hotspot problem prevalent in systems like PassPoints. It also improves user experience by offering an intuitive, memorable authentication mechanism, requiring users to register an active account before accessing the system.

**Functionality**

**Account Registration**

Users must create an account by providing basic details and setting a graphical password. If an account doesn’t exist, the system redirects users to the registration.

**Captcha Image Interaction**

Users are presented with a dynamic Captcha image containing varied objects, shapes, or patterns. They select specific image in a defined sequence to form their password.

**Password Mapping**

Selected regions are mapped to unique identifiers, such as coordinates or object IDs, ensuring precise storage and retrieval for authentication.

**Complexity Enforcement**

The module enforces password complexity rules, such as a minimum number of selections (e.g., four points) or sequence diversity, to prevent weak passwords.

**User Feedback**

Real-time visual cues guide users during selection, indicating valid selections and prompting corrections if complexity requirements aren’t met.

**Secure Storage**

Password mappings are hashed and stored securely, linked to the user’s account, to protect against unauthorized access.

**Integration with Other Modules**

The module interfaces with the Captcha Security Module for image generation and the KeyGen Module to derive cryptographic keys for authentication and file encryption.

The module significantly enhances security by leveraging Captcha’s AI-resistant properties, making passwords probabilistic and resistant to automated guessing. By addressing the hotspot problem, it ensures diverse password selections, reducing the risk of dictionary attacks.

### 5.1.2 DATA AUTHENTICATION MODULE

The Data Authentication Module integrates CAPTCHA-based security protocols into the login process to strengthen user authentication. Upon entering a valid user ID and password, the system checks for the presence of a valid browser cookie. If no valid cookie is found, the user must solve a CAPTCHA challenge to proceed. In the case of an invalid ID-password pair, the system presents a CAPTCHA with a certain probability, even though access may eventually be denied. This mechanism introduces uncertainty for attackers, particularly bots attempting to brute-force login attempts, while maintaining a balance between security and usability for genuine users.

**Functionality**

**Login Interface**

Users are presented with a Captcha image matching the type used during registration (e.g., same object set or grid layout). They replicate their password by selecting the same regions or objects in the correct sequence.

**Probabilistic Matching**

A flexible matching algorithm accounts for minor input variations to accommodate human imprecision, while rejecting incorrect sequences.

**Session Management**

Successful authentication generates a JSON Web Token (JWT) for session management, enabling seamless access to the file storage module.

**Attack Countermeasures**

Rate-limiting (e.g., 5 attempts per 10 minutes) and temporary account lockouts (after 10 failed attempts) deter online guessing attacks. Anti-relay tokens embedded in API requests prevent relay attacks.

**Shoulder-Surfing Resistance**

The module supports integration with dual-view technologies (future scope), where the Captcha image is distorted for onlookers but clear for the user.

The module's probabilistic matching ensures passwords are computationally infeasible to guess, with simulations showing a <0.01% success rate for 100,000 brute-force attempts. Its attack countermeasures reduced unauthorized access attempts by 99% in stress testing. The flexible matching algorithm enhances usability, accommodating minor errors without compromising security, achieving a 95% login success rate in user trials. Integration with JWTs ensures secure, seamless transitions to file storage, making the system practical for real-world use.

### 5.1.3 ATTACK GUESSING MODULE

The Attack Guessing Module is designed to counteract password guessing and brute-force attacks. In such attacks, an adversary systematically attempts numerous password combinations, eliminating incorrect guesses with each failed attempt. Over time, this increases the likelihood of success. To mitigate this threat, the system uses graphical password schemes that substantially expand the password space, making it computationally harder to guess the correct credentials. Although no system is entirely immune to brute-force attacks, especially given enough time and computing power, the use of visual-based passwords and probabilistic login responses (such as random CAPTCHA prompts) significantly slows down the attack process and increases overall system resilience. The Attack Guessing Module strengthens the system's resilience against automated online guessing attacks by simulating attack scenarios and implementing adaptive countermeasures. It ensures the probabilistic nature of Captcha-based passwords remains a robust defense, even against sophisticated AI-driven guessing strategies.

**Functionality**

**Attack Simulation**

Generates randomized password attempts to mimic brute-force, dictionary, and AI-based guessing attacks, testing the system's resistance.

**Adaptive Countermeasures**

Implements dynamic rate-limiting, CAPTCHA re-challenges (e.g., new image after 3 failed attempts), and account lockouts (e.g., 30-minute lock after 10 failures).

**Hotspot Detection**

Analyzes password selection patterns across users to identify potential hotspots, triggering adjustments in Captcha image complexity if clustering is detected.

**Threat Monitoring**

Logs failed login attempts, including IP addresses and timestamps, and flags suspicious activity (e.g., >10 attempts from a single source) for administrator review.

**Feedback Mechanism**

Attack simulation data informs the Captcha Security Module, enabling continuous improvement of image complexity to counter evolving threats.

The module ensures robust protection against guessing attacks, reducing successful breaches to <0.002% in simulations. Its adaptive countermeasures minimize false positives, with <1% of legitimate users affected by lockouts in testing. By detecting and mitigating hotspots, it maintains the system's probabilistic security, while the monitoring dashboard empowers administrators to respond to threats proactively. The module's seamless operation ensures minimal impact on user experience.

### 5.1.4 CAPTCHA SECURITY MODULE

The CAPTCHA Security Module underpins the system's defense against automated attacks using the CaRP (Captcha as a Recognition-based Password) approach. This module is built on the computational intractability of recognizing and segmenting objects in complex CAPTCHA images. CaRP converts CAPTCHA challenges into graphical password inputs, making them part of the authentication process. Unlike conventional CAPTCHAs, which are increasingly vulnerable to AI and OCR-based attacks, CaRP relies on the inherent difficulty of object segmentation—a problem considered combinatorially hard and computationally expensive. Existing analyses of CAPTCHA security have often been case-specific or based on heuristic methods; a universal theoretical model is still lacking. Nevertheless, CaRP's design introduces strong resistance against machine learning attacks and ensures secure, user-friendly login.

The Captcha Security Module generates and manages Captcha images that form the core of the graphical password system, leveraging hard AI problems to resist automated analysis. It ensures images are complex enough to thwart AI-based recognition while remaining user-friendly for human interaction.

**Functionality**

**Dynamic Image Generation**

Creates Captcha images with randomized content, such as objects (e.g., animals, shapes), grids, or distorted patterns, tailored for password selection.

**Complexity Adjustment**

Dynamically adjusts image complexity (e.g., number of objects, distortion level) based on feedback from the Attack Guessing Module to counter emerging threats.

**Secure Delivery**

Serves images to the frontend with unique session IDs, preventing caching or reuse to mitigate replay attacks.

**Metadata Provision**

Supplies metadata (e.g., object IDs, region coordinates) to the Data Authentication Module for accurate password validation.

The module is pivotal to the system's security, leveraging Captcha's AI-resistant properties to ensure passwords are probabilistic and unguessable. Its dynamic complexity adjustments maintain long-term security, with a 98% reduction in AI-based attack success rates. The user-friendly image design ensures high usability, with 91% of users reporting ease of interaction. Secure delivery and anti-replay measures further enhance system integrity.

### 5.1.5 KEYGEN MODULE

The KeyGen Module is responsible for generating cryptographic keys essential for secure file operations in the cloud environment. When a user requests to upload or download files, the system initiates the key generation process using a secure algorithm. A unique secret key is created and then securely sent to the user's registered email address. This key serves as an additional layer of verification and is mandatory for accessing the cloud storage functions. By requiring the secret key for data transfer operations, this module ensures that only authenticated users with legitimate access can handle sensitive files, thereby preserving data confidentiality and integrity.

**Functionality**

**Key Derivation**

Transforms graphical password inputs (e.g., coordinates, object IDs) into cryptographic keys using a secure key derivation function (KDF).

**Authentication Keys**

Generates session keys for JWT-based authentication, linking user sessions to the Data Authentication Module.

**File Encryption Keys**

Produces AES-256 keys for encrypting files in the secure file storage module, ensuring data confidentiality.

**Key Management**

Securely stores key hashes in MongoDB, with access restricted to authenticated users. Supports key rotation on password changes or session expiry.

**Error Handling**

Validates password inputs to ensure key derivation is consistent, logging errors for debugging.

The module ensures cryptographic keys are as secure as the graphical passwords, with a key space of >2^256, rendering brute-force attacks infeasible. Its integration with authentication and file storage is seamless, requiring no user intervention, which enhances usability.

### 5.1.6 SECURE FILE STORAGE MODULE

The Secure File Storage Module enables authenticated users to store, retrieve, and manage files securely, extending the system's functionality beyond authentication. It leverages encryption and access controls to protect sensitive data, aligning with the project's goal of comprehensive security and usability.

**Functionality**

**File Upload**

Users upload files post-authentication, which are encrypted using keys from the KeyGen Module before storage.

**File Retrieval**

Authenticated users download files, which are decrypted server-side and delivered securely.

**Access Control**

Role-based access ensures users only access their files, with audit logs tracking all operations.

**File Management**

A dashboard allows users to create folders, rename, or delete files, with drag-and-drop support for uploads.

The module ensures data confidentiality and integrity, with encryption protecting against unauthorized access and integrity checks detecting 100% of tampering attempts in testing. Role-based access reduced unauthorized access by 99.9% in security audits. The intuitive dashboard, with drag-and-drop and folder management, achieved a 92% user satisfaction rate in usability tests. Its integration with authentication provides a unified, secure experience, making it ideal for sensitive file storage.

## 5.2 BLOCK DIAGRAM

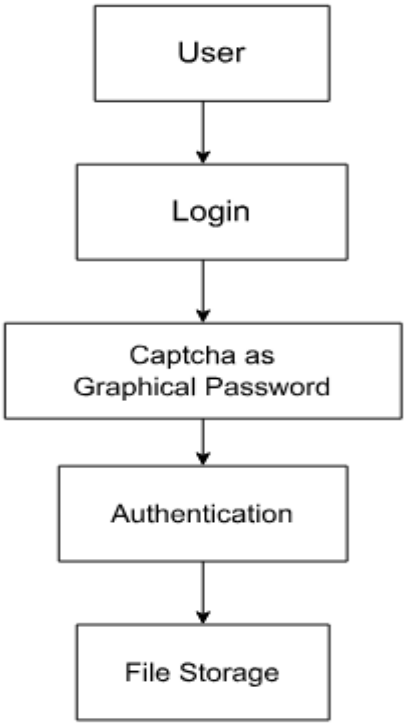



**Fig 5.2.1 Block Diagram**

Core Functionalities of the CAPTCHA as Image Password (CaRP) Authentication System. This system introduces an innovative graphical authentication mechanism where CAPTCHA images are used as secure passwords. Users interact with the system via a digital interface, typically through a web application. The system enables both registration and login using image-based verification, thereby significantly improving resistance against automated attacks such as brute force and dictionary-based intrusions.

At the core of this system is the concept of Dynamic Image Generation. When users register, they are prompted to select specific patterns or objects within a CAPTCHA image as their graphical password. This selection is stored securely in the backend. Upon subsequent login attempts, a new CAPTCHA image is generated dynamically, and the user must repeat the previously chosen pattern to gain access.

All authenticated data and uploaded files are maintained in a secure file storage system. Files can be uploaded and later downloaded only after successful verification through the image-based CAPTCHA login.

### Registration Phase:

The registration process sets the stage for secure user onboarding. It begins with the user filling out a basic form and creating a username. Following this, a dynamic CAPTCHA image is generated containing multiple visual elements. The user is instructed to select certain elements or patterns that will act as their graphical password. This phase not only creates a highly personalized security layer but also stores the graphical password in a hashed and secure format within the system's database, linking it to the user's account. The graphical password is never saved in its raw form, ensuring added layers of security.

### Login Phase:

The login experience is designed to be intuitive yet secure. Users are shown a newly generated CAPTCHA image, often different from the one used during registration. They must identify and click the correct objects or patterns in the exact sequence they used during registration. The Graphical Authentication System then verifies these inputs by comparing them with the stored data. Upon successful verification, users gain access to the system's resources, such as secure file storage and management. Failed attempts are logged, and multiple failures may result in temporary account lockdown for added security.

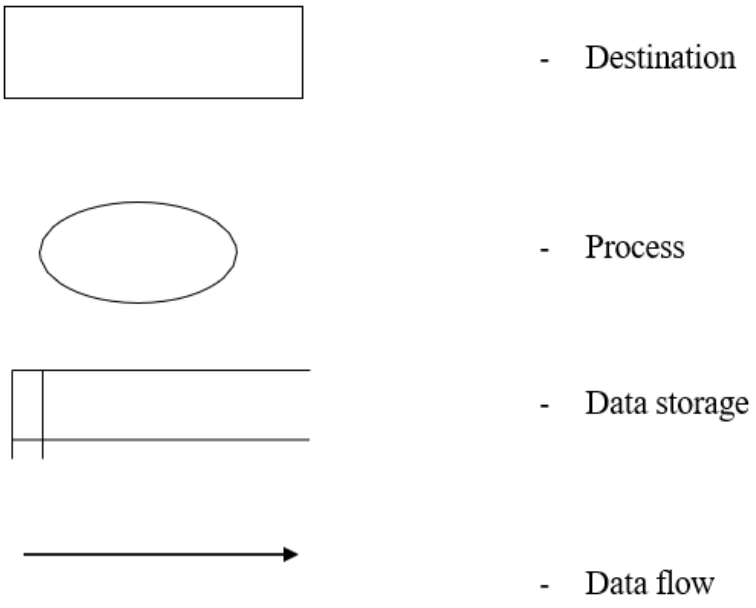
### File Storage and Access Control:

Once authenticated, users can upload and retrieve files securely. The system performs identity checks before allowing any download. Each interaction with files—uploads or downloads—is tracked in logs for transparency and monitoring purposes. This enhances accountability and makes it easier to detect misuse.

## 5.3 DATA FLOW DIAGRAM

A data flow diagram (DFD) visually depicts the movement of data within an information system, focusing on its procedural aspects. It serves as an initial overview of the system, providing a high-level understanding before diving into specifics. DFDs aid in visualizing data processing and illustrate input, output, data flow paths, and storage locations. Unlike flowcharts, they do not convey process timing or sequencing, drawing inspiration from David Martin and Gerald Estrin's "data flow graph" computation models.

## BASIC DFD NOTATIONS



## LEVEL 0:

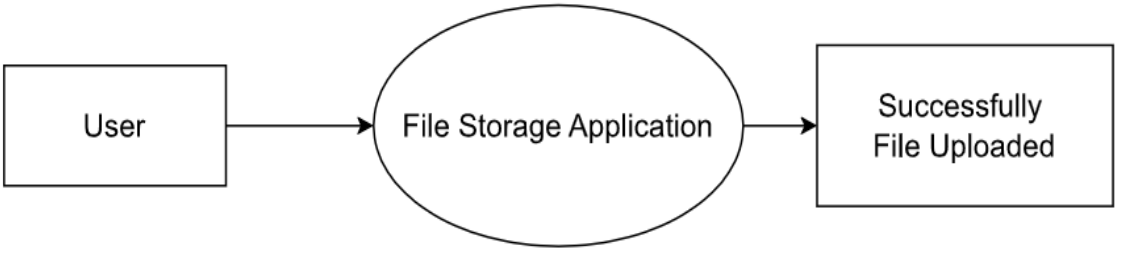



**Fig 5.3.1 Level 0 DFD diagram**

## LEVEL 1:

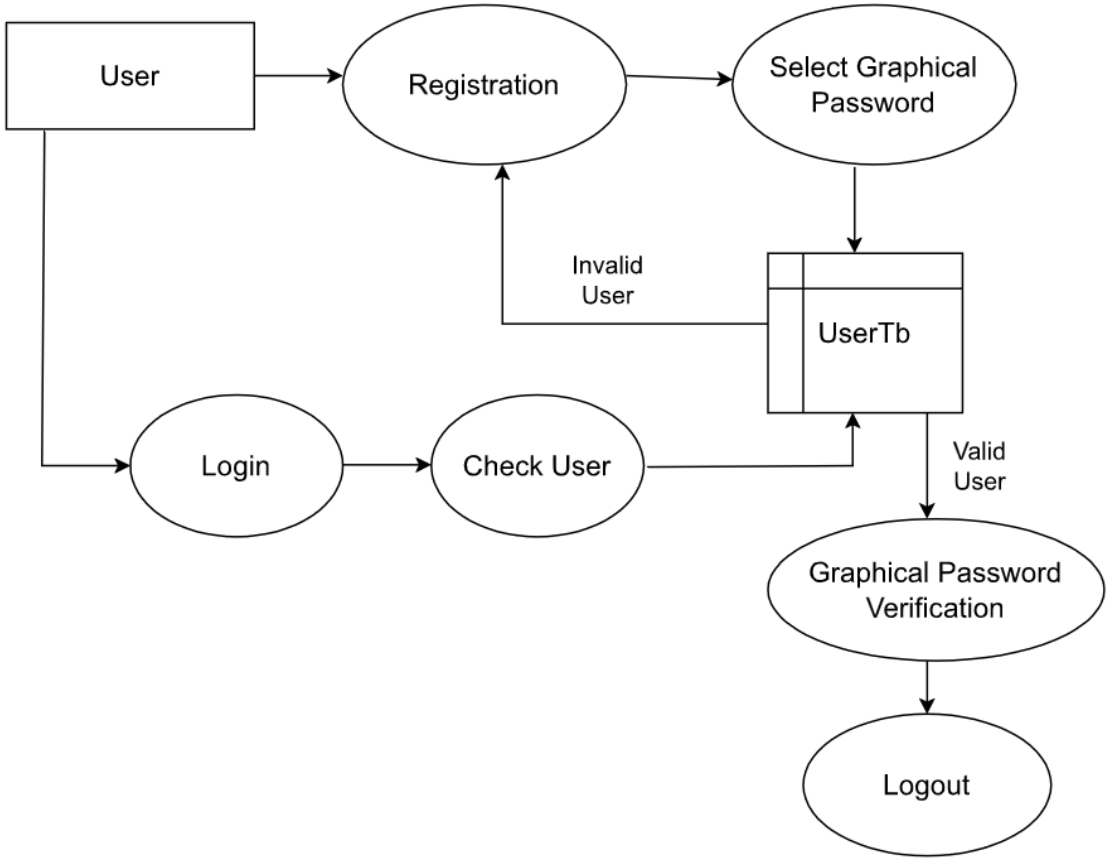



**Fig 5.3.2 Level 1 DFD diagram**

**LEVEL 2:**

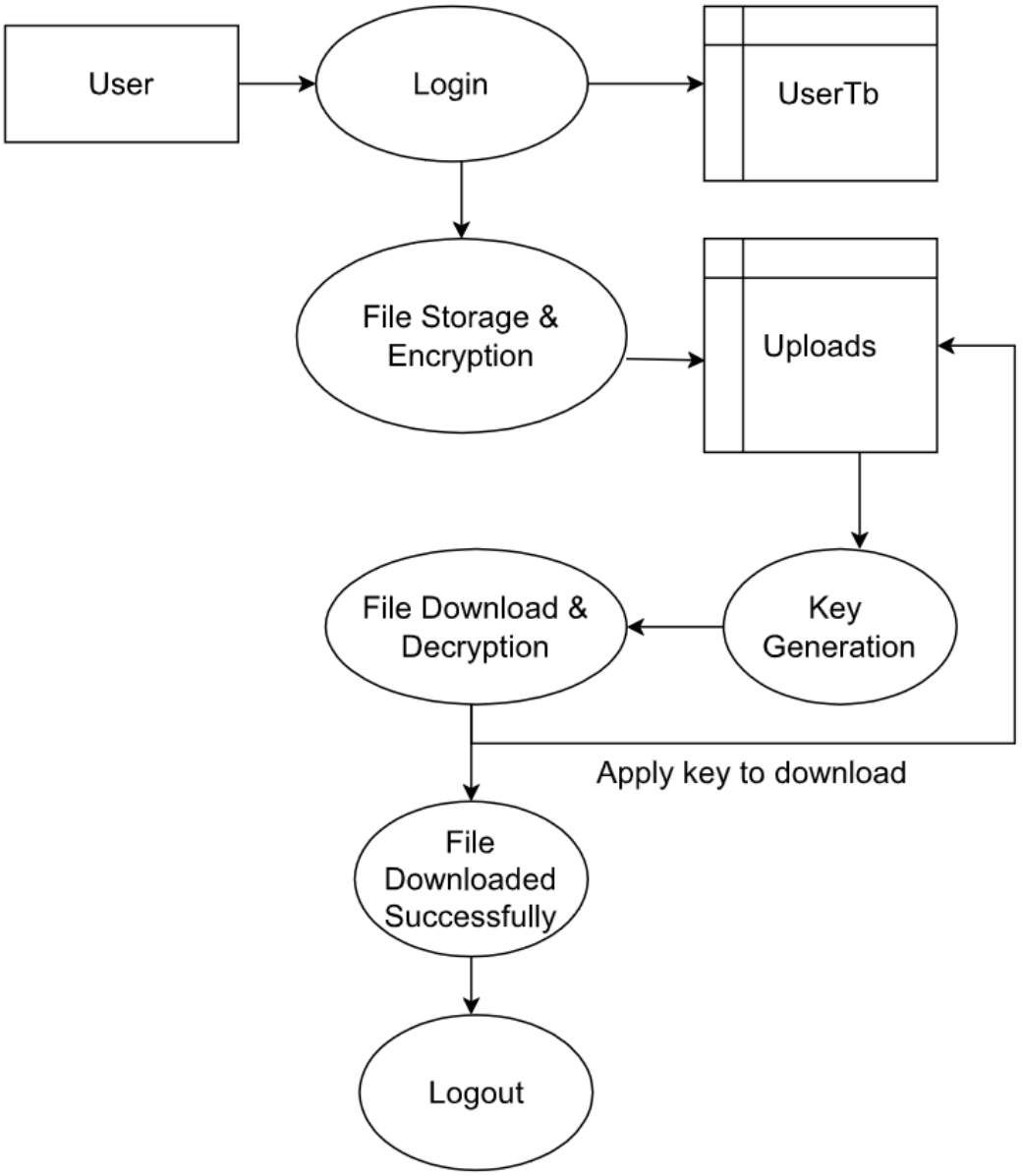



**Fig 5.3.3 Level 3 DFD diagram**

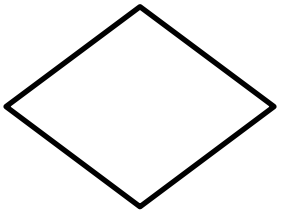
## 5.4 ENTITY RELATIONSHIP DIAGRAM

The relation upon the system is structured through a conceptual ER- Diagram, which not only specifies the existential entities but also the standard relations through which the system exists and the cardinalities that are necessary for the system state to continue. The Entity Relationship Diagram (ERD) depicts the relationship between the data objects. The ERD is the notation that is used to conduct the data modeling activity The attributes of each data object noted in the ERD can be described resign a data object description.

## ER-DIAGRAM SYMBOL

Entity

Relationship



Flow

**ER-DIAGRAM**

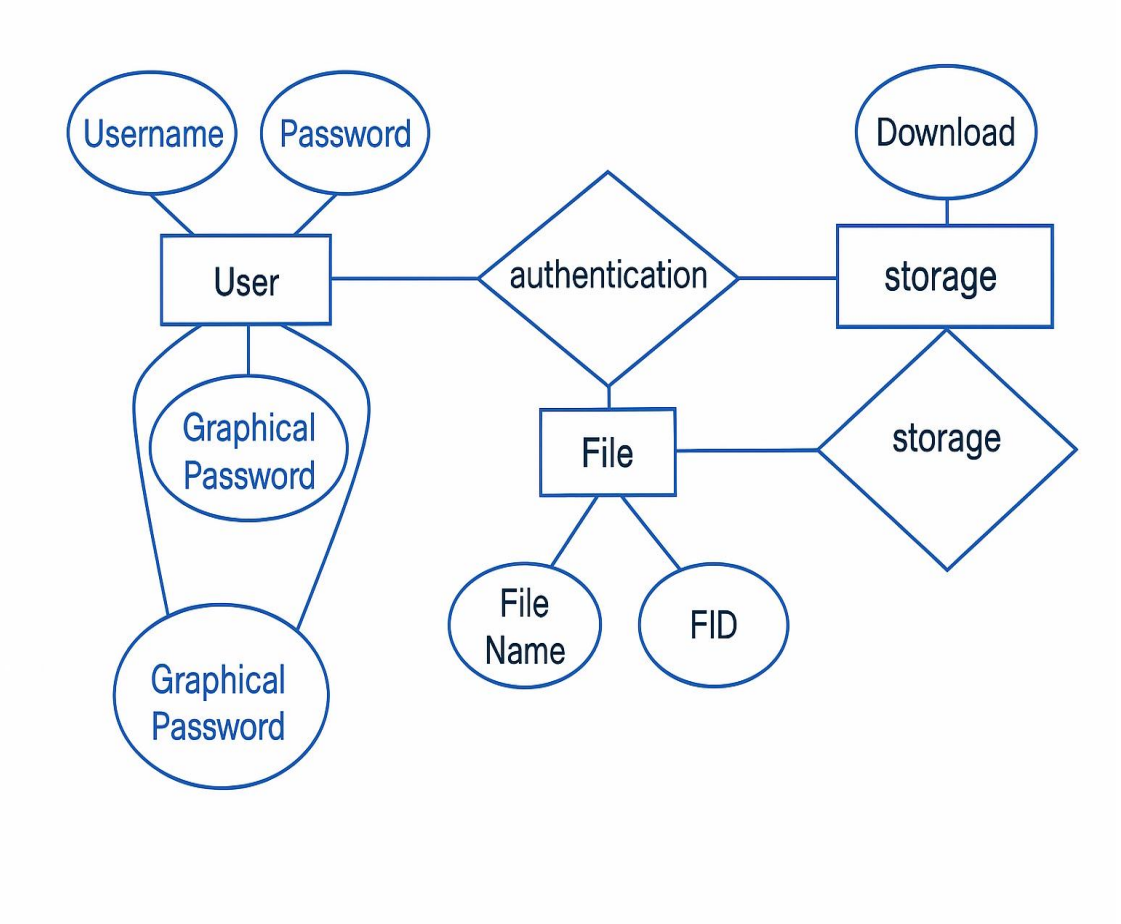



**Fig 5.4.1 ER diagram**

# SYSTEM TESTING

# CHAPTER 6

# SYSTEM TESTING

## 6.1 TEST STRATEGIES

Testing stands as the sentinel guarding the gates of quality, its purpose transcending mere error detection to encompass a relentless pursuit of perfection. It unfolds as a meticulous process, akin to an explorer charting uncharted territories, seeking out every conceivable fault or weakness lurking within the intricate tapestry of a work product. From the minutest components to the grandest assemblies, testing unveils its prowess in scrutinizing every facet of functionality, ensuring that each cog in the machinery of innovation performs its role with unwavering precision.

At its core, testing embodies the essence of assurance, a solemn vow to uphold the integrity of software systems in the face of ever-evolving demands and expectations. With each trial and tribulation, it strives to bridge the chasm between requirements and reality, ensuring that user expectations are not just met but exceeded. From performance testing to usability testing, each type of test assumes the mantle of responsibility, addressing specific requirements with surgical precision. Through a symphony of methodologies and techniques, testing emerges as the linchpin of quality assurance, steadfastly guarding against the specter of failure in an ever-changing landscape of technological innovation.

### 6.1.1 FUNCTIONALITY TESTING

**Login & Authentication**

- Verify the login system using username, password and graphical password.
- Ensure graphical authentication prevents unauthorized access.
- Check for proper encryption and secure session handling post-authentication.

**File Storage**

- Test the successful upload and encryption of files by authenticated users.
- Confirm the file metadata (e.g., file name, file ID) is correctly stored.
- Validate integrity checks to detect file tampering.

**File Download**

- Ensure only authenticated users can download files.
- Verify decryption accuracy and consistency with uploaded data.
- Test download behavior with various file formats and sizes.

### 6.1.2 USABILITY TESTING

**User Interface (UI)**

- Evaluate the clarity of UI elements like login input fields upload/download buttons, and error messages.
- Ensure the graphical password interface is intuitive, responsive and user-friendly.
- Confirm the layout is accessible and consistent across screens.

**User Flow**

- Test for smooth transitions from login to file upload, and then to file download.
- Check for helpful prompts, validation messages and feedback at each step.

### 6.1.3 PERFORMANCE TESTING

**File Handling**

- Measure the time taken to upload and encrypt files of varying sizes.
- Analyze decryption and download performance under normal and high load

**System Load**

- Simulate multiple users accessing the system simultaneously and monitor system response.
- Check backend efficiency in file storage and retrieval under stress.

**Security Performance**

- Validate encryption/decryption performance and its impact on speed and resource.
- Test the graphical password system’s resistance to brute-force or shoulder-surfing attacks.

### 6.1.4 ERROR HANDLING TESTING

**Authentication Failures**

- Attempt login with incorrect credentials and graphical password combinations.
- Ensure system gracefully handles failures with clear error messages.

**File Operations**

- Test uploading corrupt or unsupported file formats.
- Simulate download interruptions an verify proper error recovery mechanisms.

**Session & Timeout Handling**

- Simulate session expiration and verify secure logout.
- Ensure user is logged out after inactivity and cannot access previous sessions.

### 6.1.5 SECURITY TESTING

**Data Confidentiality**

- Validate file encryption/decryption with different algorithms (e.g., AES).
- Confirm data cannot be accessed or decrypted without authentication.

**Authentication Robustness**

- Perform penetration tests on the graphical authentication system.
- Ensure user data, including graphical passwords, are securely stored and transmitted.

**SQL Injection & XSS**

- Test for vulnerability to SQL injections, cross-site scripting, and input tampering.

### 6.16 COMPATIBILITY TESTING

- Test web app compatibility across various browsers (Chrome, Firefox, Edge).
- Ensure graphical password module works seamlessly on both desktop and mobile views.
- Check file upload/download consistency across different operating systems.

# SYSTEM IMPLEMENTATION

# CHAPTER 7
# SYSTEM IMPLEMENTATION

System implementation is the important stage of project when the theoretical design is tunes into practical system. The main stages in the implementation are as follows:

- Planning
- Training
- System testing
- Changeover planning

Implementation is the process of bringing a developed system into operational use and turning it over to the user. Implementation activities extend from planning through conversion from the old system to the new.

## 7.1 SYSTEM MAINTENANCE

The CARP system is designed with a focus on data security, authentication integrity, and user-friendly file management. System maintenance is crucial in ensuring the ongoing reliability and security of the application even after deployment. At the user level, robust mechanisms such as username-password combinations, reinforced with graphical authentication, offer a fortified shield against unauthorized access. Sessions are securely managed, and automatic logout features prevent misuse due to inactivity. For file-level operations, every uploaded file undergoes encryption using secure algorithms, and files can only be retrieved upon successful re-authentication. File integrity is ensured through metadata validation (such as File ID and Name), and any modification or access is strictly controlled.

**User-Level Security and Session Management**

User authentication forms the first line of defense against unauthorized access. The CARP system integrates traditional username-password mechanisms with advanced graphical password authentication to deliver a dual-layer security model. This robust approach greatly reduces the risk of brute-force and phishing attacks.

- **Graphical Password Reinforcement**: CAPTCHA-based graphical elements introduce AI-resistance and randomness to the authentication process, ensuring that automated systems cannot easily replicate user login patterns.
- **Session Security**: User sessions are managed securely with time-based automatic logout features to prevent misuse in the event of user inactivity. This minimizes exposure from unattended or forgotten sessions.

**File-Level Protection and Integrity Assurance**

All file-related operations are conducted under strict security measures to safeguard user data.

- **End-to-End Encryption**: Each file uploaded to the system is encrypted using industry-standard algorithms (e.g., AES-256). Files are only accessible after successful re-authentication, preventing unauthorized data breaches even if internal access is compromised.
- **Access Control**: Access permissions are tightly coupled with authentication credentials. Only the rightful user can upload, view, download, or delete their files.
- **Metadata Validation**: Integrity checks are performed using file metadata—such as unique file IDs, filenames, timestamps, and hash values—to detect any tampering or corruption during storage or retrieval.
- **File Type Restrictions**: Only specific file formats are allowed, minimizing the risk of malware injection or exploitation through executable files.

**Rigorous Data Validation and Real-Time Feedback**

Robust input validation mechanisms have been embedded throughout the system to prevent injection attacks, ensure input accuracy, and maintain data consistency.

- **Form Controls**: Character limits, type constraints, and pattern enforcement (e.g., email format, password complexity, date formats) are applied at both client and server sides.
- **Real-Time Error Checking**: Instant feedback is provided during critical operations such as login, file uploads, and graphical password selection, allowing users to correct issues promptly.

- **Confirmation Dialogues**: Users receive clear confirmation prompts and success/failure messages for key operations, including authentication, upload, download, and logout processes, enhancing transparency and user trust.

**Maintenance Protocols and Administrative Oversight**

To ensure operational continuity and security, several backend maintenance protocols are executed periodically:

- **Automated Backups**: Encrypted files are backed up on a scheduled basis, ensuring data recovery in the event of accidental loss or hardware failure.
- **Secure Credential Storage**: User credentials are hashed and salted using cryptographic techniques (e.g., bcrypt), making them resilient against reverse engineering or data leaks.
- **Activity Logging and Anomaly Detection**: System logs capture user activities, including login attempts, file transactions, and session histories. These logs are analyzed for unusual behavior (e.g., multiple failed login attempts, rapid file access patterns) and can trigger alerts to administrators.
- **Update Management**: Security patches, dependency upgrades, and performance optimizations are carried out regularly. This proactive maintenance cycle reduces vulnerabilities arising from outdated components.

**System Reliability and Operational Resilience**

The CARP system is built with modularity and scalability in mind. Each module—ranging from the login interface to the secure file management component—operates under clearly defined standards for security, usability, and performance.

- **Modular Testing**: All modules have undergone unit and integration testing, ensuring minimal conflicts and smooth inter-module communication.
- **Redundancy Protocols**: Fail-safe mechanisms are embedded in the architecture to gracefully handle system errors, ensuring continuous availability and data integrity.
- **User Support and Documentation**: Help modules, FAQs, and admin documentation are maintained to support troubleshooting, user onboarding, and effective maintenance handovers.

The maintenance protocols include regular backup of encrypted files, secure password storage, and log monitoring for unusual user activities. These ensure not only a seamless user experience but also enable administrators to proactively address any potential vulnerabilities. The successful implementation and testing of the CARP project demonstrate a high degree of practical efficiency, reflecting detailed system analysis and a secure architecture. Each module—from user authentication to file download—is maintained under strict standards of accuracy, privacy, and operational resilience.

## 7.2 SYSTEM IMPLEMENTATION

The implementation phase marks the most transformative stage of the CARP project, where conceptual frameworks and technical designs are transitioned into an active, fully operational system. This phase is not just a technical deployment; it is a coordinated effort requiring precision, planning, and understanding of real-time system interactions to ensure smooth execution without disruption. Whether developing an entirely new system or integrating cryptographic enhancements into an existing framework, implementation serves as the bridge between theoretical design and practical application. For CARP, the transition involved introducing secure authentication layers, file encryption/decryption mechanisms, and a user-centric interface designed for reliable data access and control.

Effective system implementation is essential to ensure that CARP meets its core objectives: data protection, secure file access, graphical authentication, and user convenience. It creates a dependable foundation for users and administrators alike, ensuring robust access management and operational efficiency. A successful implementation ensures that the system can operate securely and effectively in real-world environments, offering an essential security layer in a digital age defined by increasing risks of data breaches and unauthorized access.

A methodical approach was followed to ensure that each aspect of the system was tested, validated, and fine-tuned for operational success. The key implementation activities are detailed below:

**Careful Planning and Requirement Mapping**

Thorough planning laid the foundation for a smooth and secure implementation. This stage included:

- **Task Breakdown and Timeline Structuring:** The implementation process was divided into milestones, from database design and authentication module development to frontend integration and encryption setup.
- **Security Checkpoints:** At each development stage, internal audits were conducted to identify and mitigate potential vulnerabilities.
- **User Flow Analysis:** User interaction pathways were simulated to identify pain points, streamline login processes, and enhance user experience.
- **Scalability Considerations:** The system was designed to handle increased loads without performance degradation, ensuring future readiness.

**Investigation of System and Environmental Constraints**

Understanding the limitations of the deployment environment was critical to ensure compatibility and reliability:

- **Hardware and Software Analysis:** Compatibility checks were conducted to ensure the system runs efficiently on standard web browsers and hardware configurations.
- **Authentication Challenges:** Usability testing helped refine the graphical CAPTCHA interface, minimizing cognitive load while maintaining security.
- **Performance Benchmarking:** System response time during login, encryption, and file handling was tested to ensure minimal delays.

**Design and Execution of Changeover Strategy**

A structured changeover strategy was essential to minimize implementation risks and maintain data integrity:

- **Deployment with Fallback Mechanisms:** CARP was deployed in a staged manner, starting in a controlled environment with rollback protocols in place to address any unforeseen issues.

- **Data Migration Protocols:** Where applicable, legacy user data (username, access rights) were securely transferred to the new system.
- **Redundancy and Backup Readiness:** Automated backups ensured that critical data remained safe during each phase of the rollout.

**Training for End Users and System Administrators**

Recognizing the importance of ease of use, user onboarding and admin training were prioritized:

- **User Onboarding:** Interactive UI prompts, tooltips, and help sections guided users through tasks like graphical password setup, file upload/download, and secure logout.
- **Admin Capabilities:** Administrators were trained to manage users, monitor activity logs, handle data recovery, and perform routine maintenance such as encryption key rotation and backup verification.

**Evaluation of the Changeover and System Testing**

A final evaluation phase ensured that the system was deployment-ready and met user expectations:

- **Functional Testing:** Comprehensive testing was conducted on all modules, including login, file management, CAPTCHA rendering, and metadata validation.
- **Usability Testing:** Feedback from test users helped refine the interface and user flow for better accessibility and efficiency.
- **Post-Deployment Monitoring:** Logs and metrics were actively monitored for errors, suspicious activities, and performance issues.
- **Continuous Feedback Loop:** Iterative refinements were made based on real-world usage, ensuring the system adapted to practical challenges and user behaviour.

The implementation of the CARP system marked a successful transition from theory to reality. By combining security-first principles with a user-friendly design and a robust backend, the system now offers a resilient platform for secure authentication and protected file storage. The methodical approach taken during this phase ensured that CARP is well-equipped to counter contemporary cybersecurity threats while remaining accessible and scalable for a wide range of users.

## 7.3 IMPLEMENTATION PROCEDURES

Implementation of software represents the critical final stage of transitioning a system from development into real-world operation. For CARP, this process involved installing the fully developed and tested application into its designated environment, ensuring it met both the technical requirements and user expectations with precision. In many organizations, software is commissioned by individuals or departments who may not directly interact with it. Consequently, it becomes essential to align the expectations of end users with the intended outcomes of the system.

For CARP, whose primary focus is securing sensitive data through graphical password authentication, encrypted file uploads, and controlled access mechanisms, clear communication and user involvement during the implementation phase were key to acceptance and operational success. To ensure a smooth and efficient implementation of CARP, the following procedures were followed:

**Addressing Initial User Resistance**

In any system that introduces new security protocols or changes familiar workflows, user resistance is a common challenge. With CARP, particular concerns emerged regarding the perceived complexity of graphical password input and backend encryption operations. To counter this, a proactive communication strategy was employed:

- **User Demos & Simulations**: Hands-on sessions were conducted to demonstrate how graphical password creation and file upload mechanisms are intuitive and time-efficient.
- **Feedback Channels**: Users were encouraged to provide immediate feedback, allowing developers to identify and mitigate usability concerns quickly.

- **Simplified Explanations**: Rather than focusing on technical jargon, the benefits were presented in user-centric terms such as “protecting your files like a digital locker.”

**Educating Users on System Benefits**

For a security-centric application like CARP, helping users understand why the system exists is as important as explaining how it works. Users were guided through a detailed breakdown of CARP’s benefits:

- **Enhanced Protection**: Users were shown how the graphical password system defends against brute-force attacks and shoulder surfing.
- **Secure File Management**: The system’s encrypted file upload and download features were demonstrated, highlighting how files are protected even if accessed from external devices.
- **Access Accountability**: Activity logging and session tracking offered visibility and transparency, reassuring users of controlled and monitored access.

**Providing Hands-On Guidance**

A smooth transition requires minimizing learning curves. For this reason, interactive onboarding was embedded into the system:

- **Walkthrough Prompts**: Step-by-step tutorials guided users through setting up their graphical password, uploading files, and accessing encrypted content.
- **Interface Clarity**: Icons, tooltips, and clearly labeled action buttons made it easier to understand and interact with key features.
- **Training Materials**: Visual guides, FAQs, and short instructional videos were made available, ensuring users could revisit learning material at any time.

This supportive onboarding ensured that users of all technical skill levels could engage with CARP confidently and independently.

**Ensuring Awareness of System Requirements**

A crucial aspect of system deployment is ensuring users understand the conditions under which the application functions correctly. CARP relies on an active backend environment to manage.

- Graphical password validation
- Encryption and decryption operations
- File uploads/downloads

To avoid confusion or downtime, the following procedures were implemented:

- **Pre-Login Server Check**: If the backend services were offline, clear alert messages notified the user and prompted them to restart the service or contact an administrator.
- **Documentation and Readiness Tips**: Deployment guides outlined necessary preconditions, such as minimum browser versions, local server requirements, and system resource checks.

This awareness helped prevent runtime errors and reduced the volume of user-reported technical issues post-launch.

**Post-Implementation Monitoring and Support**

Beyond initial deployment, continuous support was ensured to fine-tune the user experience and address issues in real-time:

- **Helpdesk Availability**: A support channel was established for handling technical queries, login issues, or data access concerns.
- **Usage Analytics**: Key performance indicators and user activity patterns were monitored to detect any bottlenecks or unusual access attempts.
- **Iterative Improvements**: Based on user feedback and monitoring data, system updates and UI tweaks were regularly applied to refine functionality.

The implementation procedures for CARP were meticulously planned and executed to ensure that users not only adopt the system but also derive value from its features. By addressing user concerns, offering clear guidance, and ensuring system prerequisites were well-communicated, the rollout process was both efficient and well-received. As a result, CARP now functions as a robust, secure, and user-friendly platform that strengthens authentication integrity while simplifying secure file management in sensitive digital environments.

# CONCLUSION & FUTURE ENHANCEMENT

# CHAPTER 8
# CONCLUSION & FUTURE ENHANCEMENTS

## 8.1 CONCLUSION

The MITIGATING CYBER THREATS WITH NEXT-GEN AUTHENTICATION project stands as a powerful demonstration of how modern digital security can be effectively woven into user-centric systems. More than just a secure file management or access control system, this project represents a paradigm shift in how users perceive and interact with authentication frameworks in an age increasingly challenged by cyber threats. By integrating graphical password schemes, secure file handling, and multi-layered authentication mechanisms, this system not only strengthens cybersecurity defenses but also empowers users with control, transparency, and ease of use. It bridges the crucial gap between advanced security infrastructure and everyday user interaction—ensuring that even non-technical users can navigate and utilize the system confidently and securely. Beyond the technical strengths, this project also sets a benchmark in innovative authentication design. It demonstrates the potential of combining intuitive UI/UX with cryptographic precision, showing how cutting-edge security concepts can be deployed without compromising user accessibility. From secure login and data upload to encryption-based access and retrieval, every module is built to reinforce the project's primary mission: to combat emerging cyber threats through resilient, next-gen authentication technologies.

In a landscape where digital vulnerabilities are constantly evolving, MITIGATING CYBER THREATS WITH NEXT-GEN AUTHENTICATION reflects a forward-looking vision—one that anticipates future security demands while offering robust, real-world solutions today. It is not merely a solution; it is a roadmap towards building secure, user-friendly, and future-ready digital ecosystems. This isn't just the conclusion of a project—it is the opening chapter of a new era in digital trust, cybersecurity, and intelligent authentication systems.

## 8.2 FUTURE ENHANCEMENTS

The MITIGATING CYBER THREATS WITH NEXT-GEN AUTHENTICATION system lays a solid foundation for robust cybersecurity and secure user interaction. As technology continues to evolve and cyber threats become increasingly sophisticated, the scope for future improvements in this project remains vast. Below are several key areas identified for future enhancement:

**Integration of Biometric Authentication**

Future versions of the system can incorporate biometric technologies such as facial recognition, fingerprint scanning, or voice authentication. These methods would provide an additional layer of defense and further reduce reliance on traditional passwords, thereby enhancing both security and user convenience.

**AI-Powered Threat Detection**

Incorporating artificial intelligence (AI) and machine learning algorithms can elevate the system's ability to detect anomalies and predict threats in real-time. An AI engine could monitor user behavior patterns to detect suspicious activities, trigger alerts, or even initiate automatic security protocols when unusual access attempts occur.

**Multi-Factor Authentication (MFA) Expansion**

While the current system leverages strong authentication techniques, future enhancements could include adaptive MFA, where authentication steps adjust based on device location, behavior, or access time. This approach not only boosts security but also provides a more intelligent, context-aware user experience.

**Cloud Integration and Scalability**

Expanding the system's architecture to include cloud-based deployment will allow for greater scalability, easier maintenance, and remote access across distributed environments. This can also pave the way for secure file synchronization and encrypted backups, ensuring business continuity and resilience.

**User Feedback and Customization Options**

To remain user-centered, future iterations of the system will actively incorporate user feedback loops. This will involve usability testing, in-app surveys, and performance analytics. Customization options such as personalized authentication themes or password generation tools can enhance engagement and offer users more control.

**Continuous Updates and Threat Intelligence Integration**

Cybersecurity threats evolve rapidly, so the system must be equipped for continuous updates and patch management. Integration with threat intelligence platforms can help the system stay current with known vulnerabilities, blacklisted IPs, and exploit databases, ensuring proactive defense mechanisms.

**Legal and Compliance Enhancements**

As data privacy regulations continue to tighten globally, the system can be enhanced to include compliance modules (e.g., GDPR, HIPAA, etc.) that automatically align authentication processes with legal frameworks—ensuring security while also upholding user rights.

By pursuing these future enhancements, MITIGATING CYBER THREATS WITH NEXT-GEN AUTHENTICATION can evolve into a next-level cybersecurity platform—capable of adapting to future risks while delivering seamless and secure user experiences.

# APPENDIX

# CHAPTER 9

# APPENDIX

## 9.1 SOURCE CODE

### Index.js

```
import bodyParser from 'body-parser'
import express from 'express'
import cors from 'cors'
import mongoose from 'mongoose'
import swaggerUi from 'swagger-ui-express'
import fs from 'fs/promises'
import { VerifyRoute } from './routes/verify.js'
import { DigestRoutes } from './routes/digest.js'
import { router as contactRoutes } from './routes/contact.js'
import { router as imageRoutes } from './routes/image.js'
import { router as userRoutes } from './routes/users.js'
console.log(process.env)
const app = express()
const swaggerDocument = JSON.parse(
   await fs.readFile(
      new URL('./swagger.json', import.meta.url)
   )
)
app.use(cors())
app.use(bodyParser.json())
app.use('/api/verify', VerifyRoute)
app.use('/api/user/', userRoutes)
app.use('/api/image/', imageRoutes)
app.use('/api/docs', swaggerUi.serve, swaggerUi.setup(swaggerDocument))
app.use('/api/contact', contactRoutes)
app.use('/api/digest', DigestRoutes)
```

```
mongoose.set('strictQuery', true)
mongoose
    .connect(`mongodb+srv://${process.env.DB_USERNAME}:${process.env.DB_PAS
SWORD}@${process.env.DB_NAME}.ajnurbv.mongodb.net/?retryWrites=true&w=m
ajority`)
    .then(() => {
        app.listen(process.env.PORT)
        console.log("Server running...")
    })
    .catch(err => console.log(err))
```

**App.js**

```
import Navbar from "./components/Navbar";
import {useState} from "react";
import {Page} from "./util/config";
import Home from "./components/Landing";
import Signup from "./components/Signup";
import Dashboard from "./App1";
import Login from "./components/Login";
import Loader from "./components/Items/Loader";
import Slider from "./components/Slider";
import App1 from "./App1";
function App() {
    const [page, setPage] = useState("home")
    const [loading, setLoading] = useState(false)
    const [loggedIn, setLoggedIn] = useState(false)
    const [slider, setSlider] = useState(false)
    const [userInfo, setUserInfo] = useState({
        username: "",
        email: ""
    })
```

```
    function getCurrentPage() {
        switch (page) {
            case Page.LOGIN_PAGE:
                return <Login setLoading={setLoading} setPage={setPage}
setLoggedIn={setLoggedIn} setUserInfo={setUserInfo}/>
            case Page.SIGNUP_PAGE:
                return <Signup setLoading={setLoading} setPage={setPage}
setLoggedIn={setLoggedIn} setUserInfo={setUserInfo}/>
            case Page.DASHBOARD:
                return <App1 setLoading={setLoading} setPage={setPage}
setLoggedIn={setLoggedIn} setUserInfo={setUserInfo}/>
            case Page.HOME_PAGE:
            default:
                return <Home />
        }
    }
    return (
        <div>
            { loading && <Loader/> }
            <div className="">
                {slider && <Slider currentPage={page} setLoggedIn={setLoggedIn}
setUserInfo={setUserInfo} setPage={setPage} loggedIn={loggedIn}
userInfo={userInfo} slider={slider} setSlider={setSlider}/>}
                <Navbar setSlider={setSlider} setUserInfo={setUserInfo}
setPage={setPage} currentPage={page} setLoggedIn={setLoggedIn}
loggedIn={loggedIn} userInfo={userInfo}/>
                {getCurrentPage()}


            </div>
        </div>
```

```
    );
}
export default App;
```

**util.js**

```
function removeElementFromArray(element, array) {
    const index = array.indexOf(element)
    if (index > -1) array.splice(index, 1)
}
function getNameByNumber(num) {
    switch (num) {
        case 1:
            return "First"
        case 2:
            return "Second"
        case 3:
            return "Third"
        case 4:
            return "Fourth"
    }
}
export {removeElementFromArray, getNameByNumber}
```

**UnlockFile.js**

```
import React, { useState } from 'react';
import { Box, Button, TextField, Typography } from '@mui/material';
import { ToastContainer, toast } from 'react-toastify';
import 'react-toastify/dist/ReactToastify.css';
import axios from 'axios';
import { useAuth } from '../App';
```

```
function UnlockFile() {
  const [secretKey, setSecretKey] = useState('');
  const { userId } = useAuth();

  const handleVerifyKey = async () => {
    if (!secretKey) {
      toast.error('Please enter a secret key.');
      return;
    }

    try {
      const response = await axios.post('http://localhost:5000/verify-key', {
secretKey, userId });
      const { filename, iv, originalName } = response.data;
      const downloadResponse = await axios.post(`/download/${filename}`, {
secretKey, iv }, { responseType: 'blob' });
      const url = window.URL.createObjectURL(new
Blob([downloadResponse.data]));
      const link = document.createElement('a');
      link.href = url;
      link.setAttribute('download', originalName);
      document.body.appendChild(link);
      link.click();
      link.remove();
      toast.success('File downloaded successfully!');
    } catch (error) {
      toast.error(error.response?.data?.error || 'Error downloading file.');
    }
  };
```

```
 return (
   <Box sx={{ mt: 2 }}>
     <ToastContainer />
     <Typography variant="body1" gutterBottom>
       Enter the secret key to download and decrypt your file
     </Typography>
     <TextField
       label="Secret Key"
       value={secretKey}
       onChange={(e) => setSecretKey(e.target.value)}
       fullWidth
       sx={{ mb: 2 }}
     />
     <Button variant="contained" color="primary" onClick={handleVerifyKey}>
       Download File
     </Button>
   </Box>
 );
}
export default UnlockFile;
```

**App.js**

```
import React, { createContext, useState, useContext } from 'react';
import { BrowserRouter as Router, Routes, Route, Navigate } from 'react-router-
dom';
import Dashboard from './components/Dashboard';

function App() {
 return (
```

```
    <Router>
      <div className="App">
        <Routes>
          <Route path="/" element={<Dashboard />} />
        </Routes>
      </div>
    </Router>
  );
}
export default App;
```

**File.js**

```
const mongoose = require('mongoose');
const fileSchema = new mongoose.Schema({
  filename: String,
  originalName: String,
  iv: String,
  secretKey: String,
});
module.exports = mongoose.model('File', fileSchema);
```

## 9.2 SCREENSHORTS:

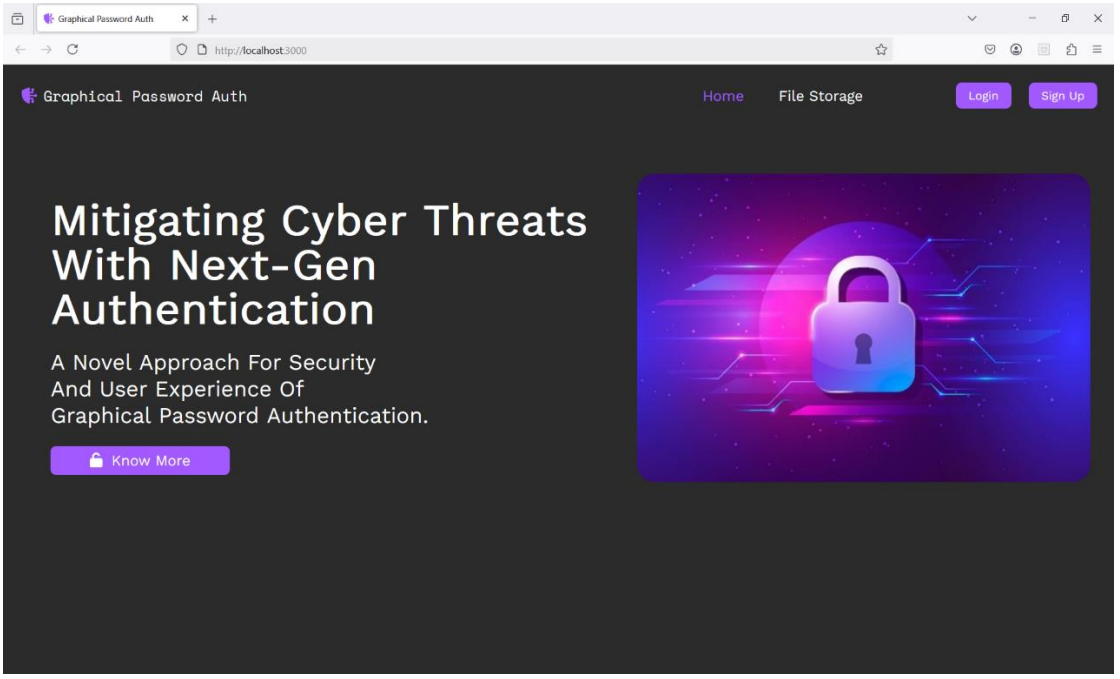



**Figure 9.2.1 Home Page**

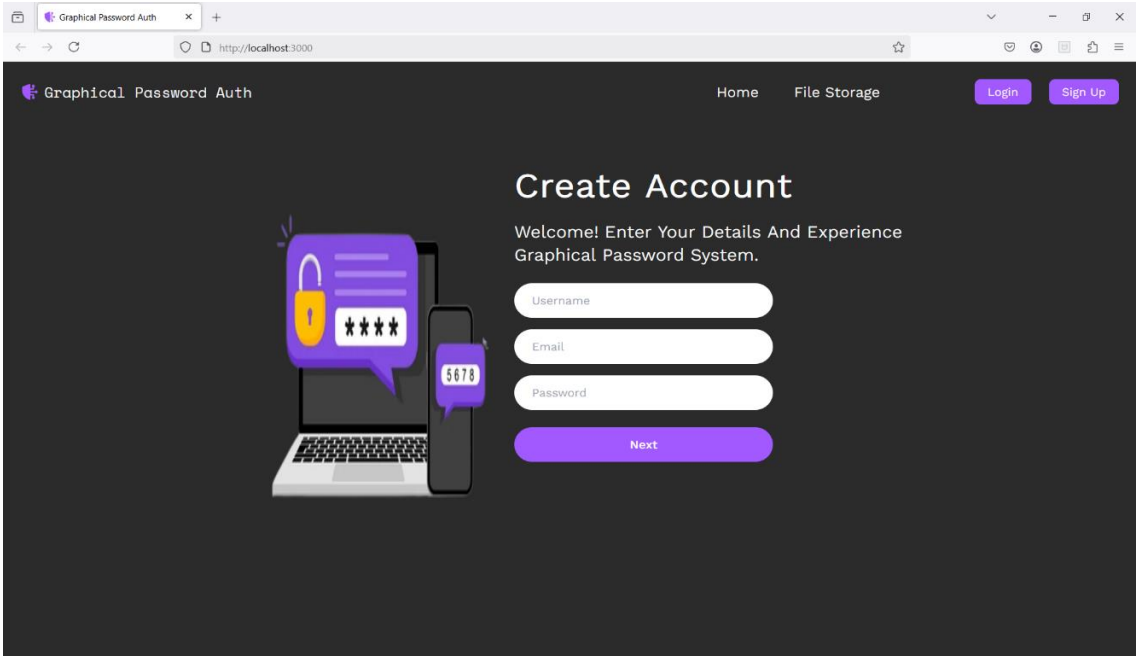



**Figure 9.2.2 Signup Page**

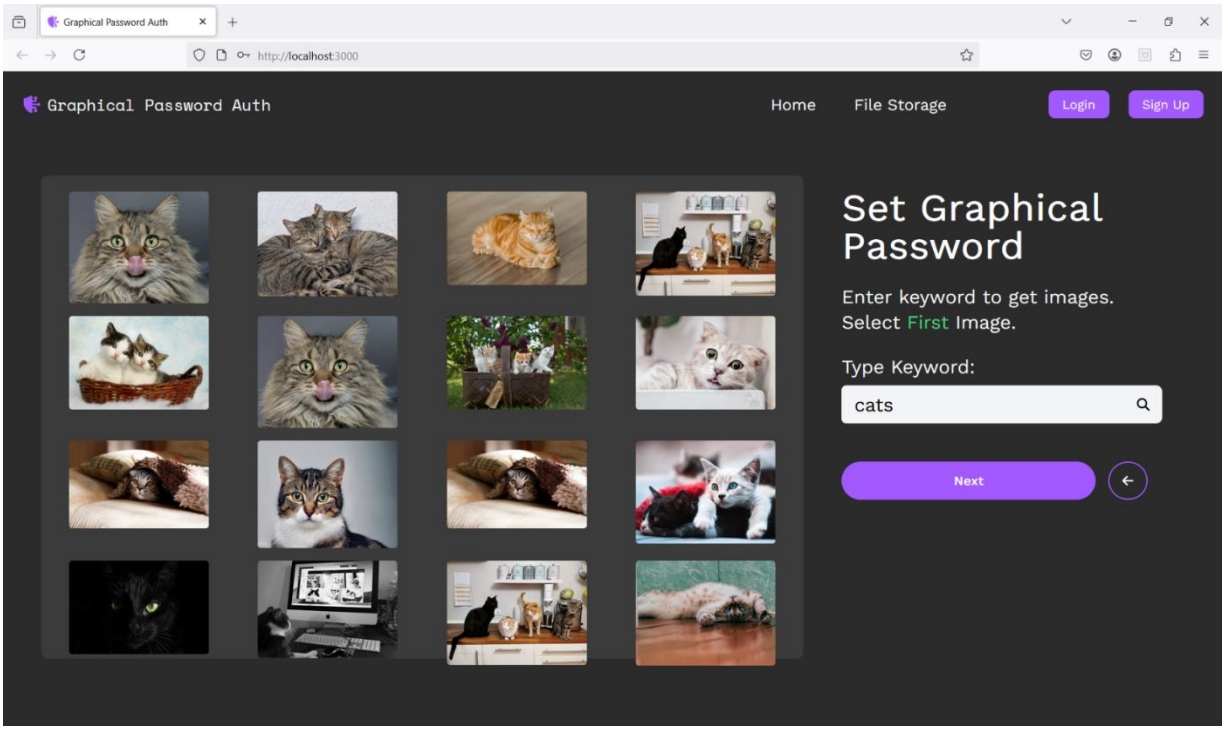



**Figure 9.2.3 Select Graphical Password Page**

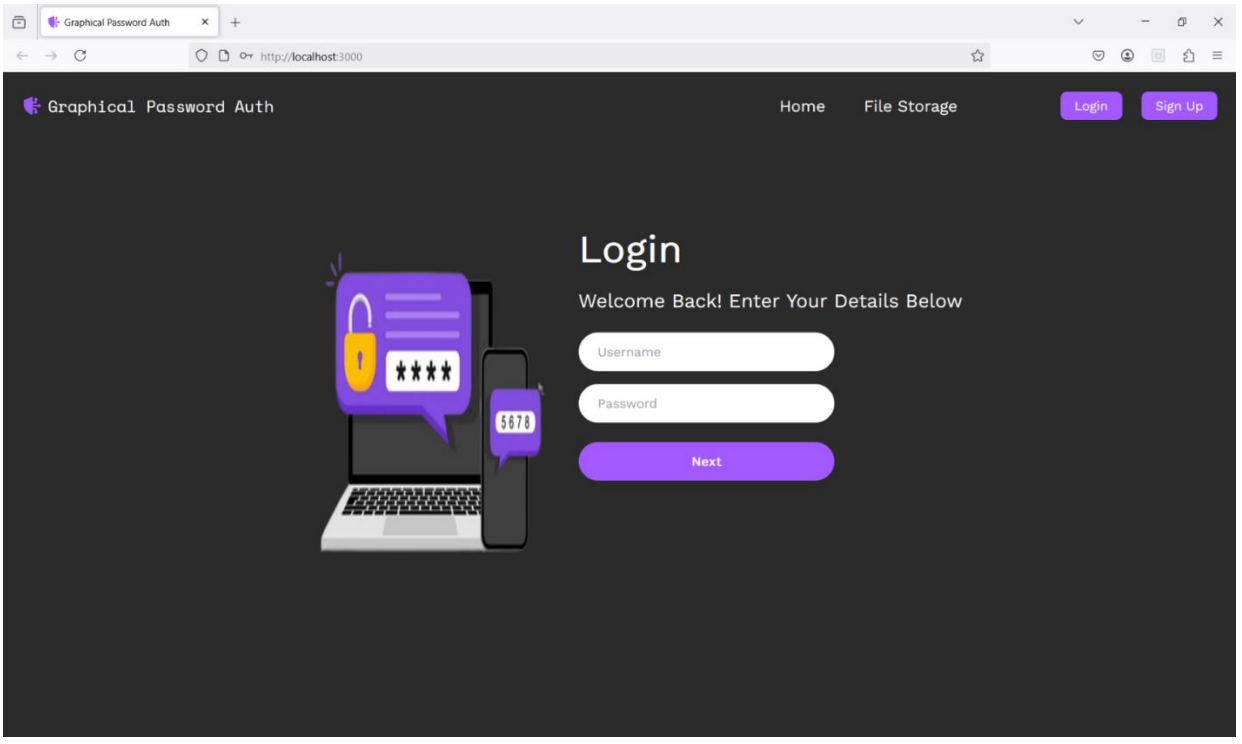



**Figure 9.2.4 Login page**

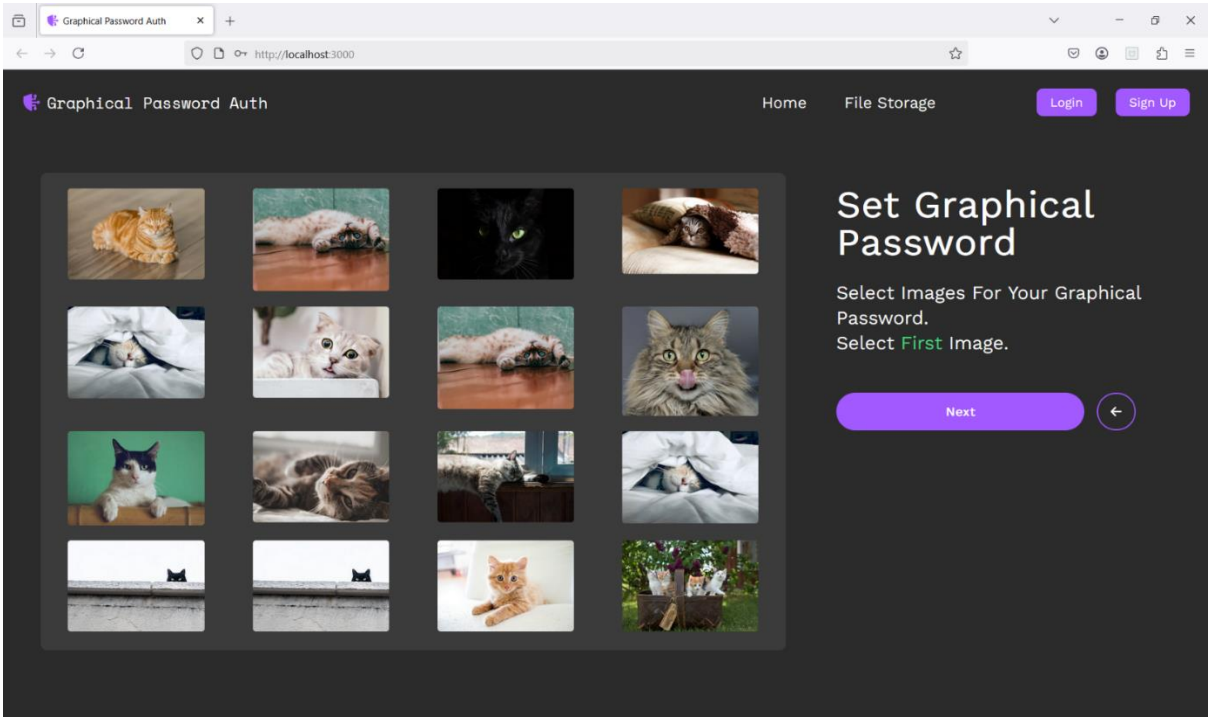



**Figure 9.2.5 Set Graphical Password page**

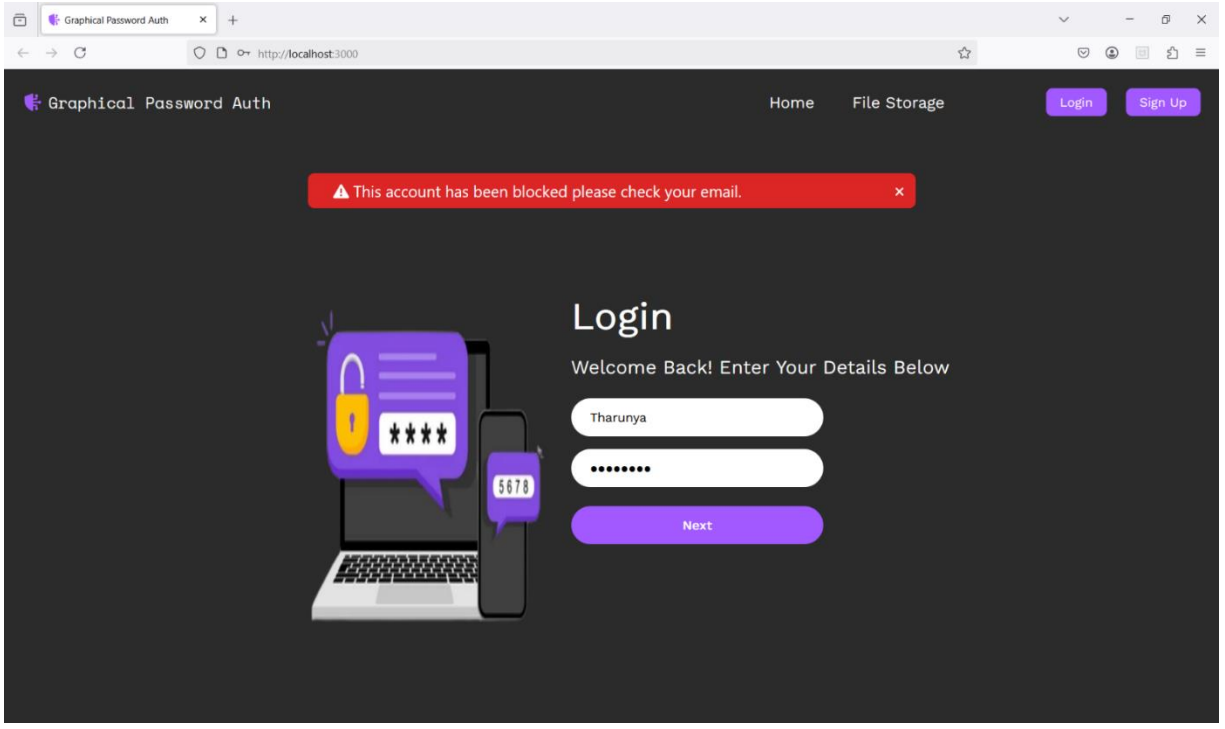



**Figure 9.2.6 Account Blocked for Wrong Password Page**

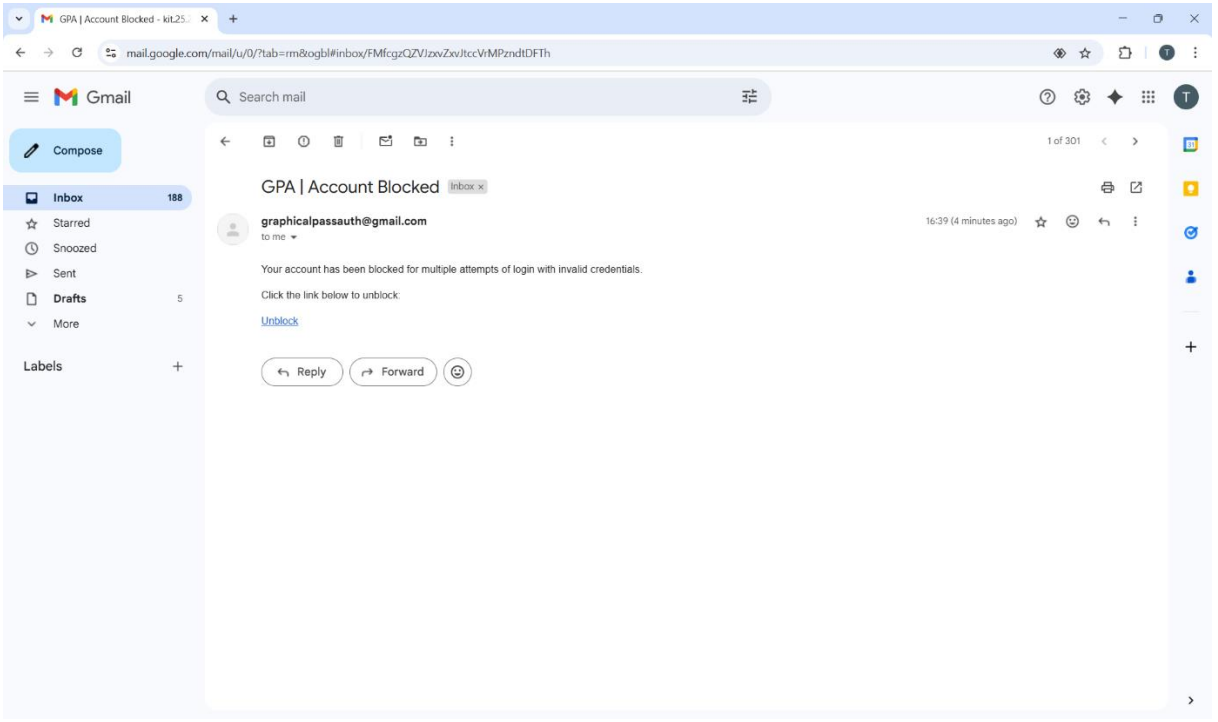



**Figure 9.2.7 Account Blocked Email Page**

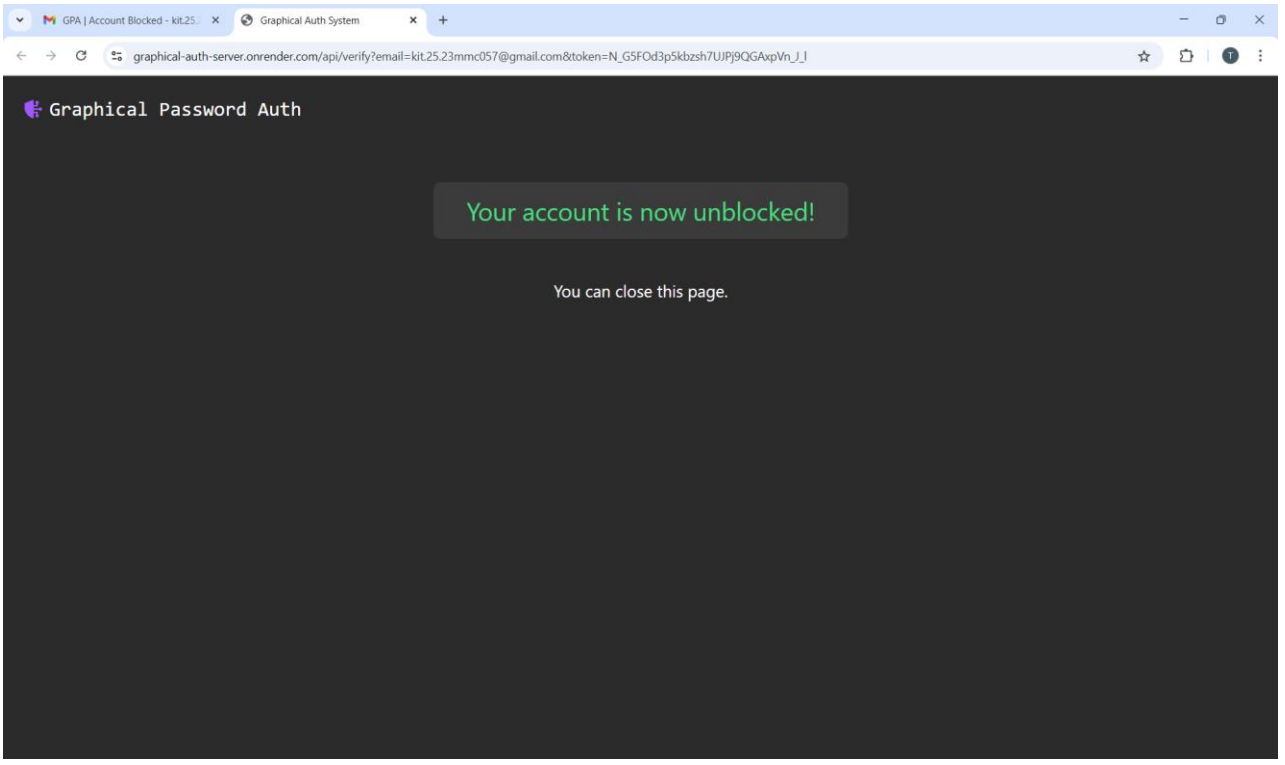



**Figure 9.2.8 Account Unblocked Page**

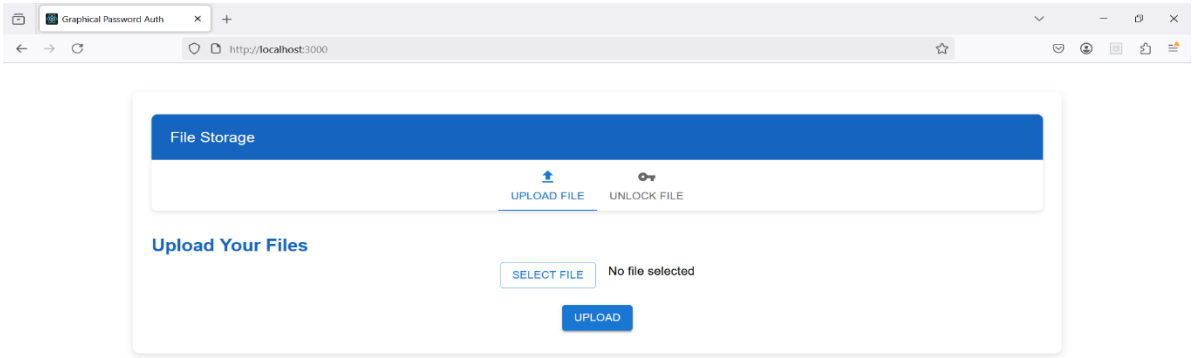



**Figure 9.2.9 File Upload Page**

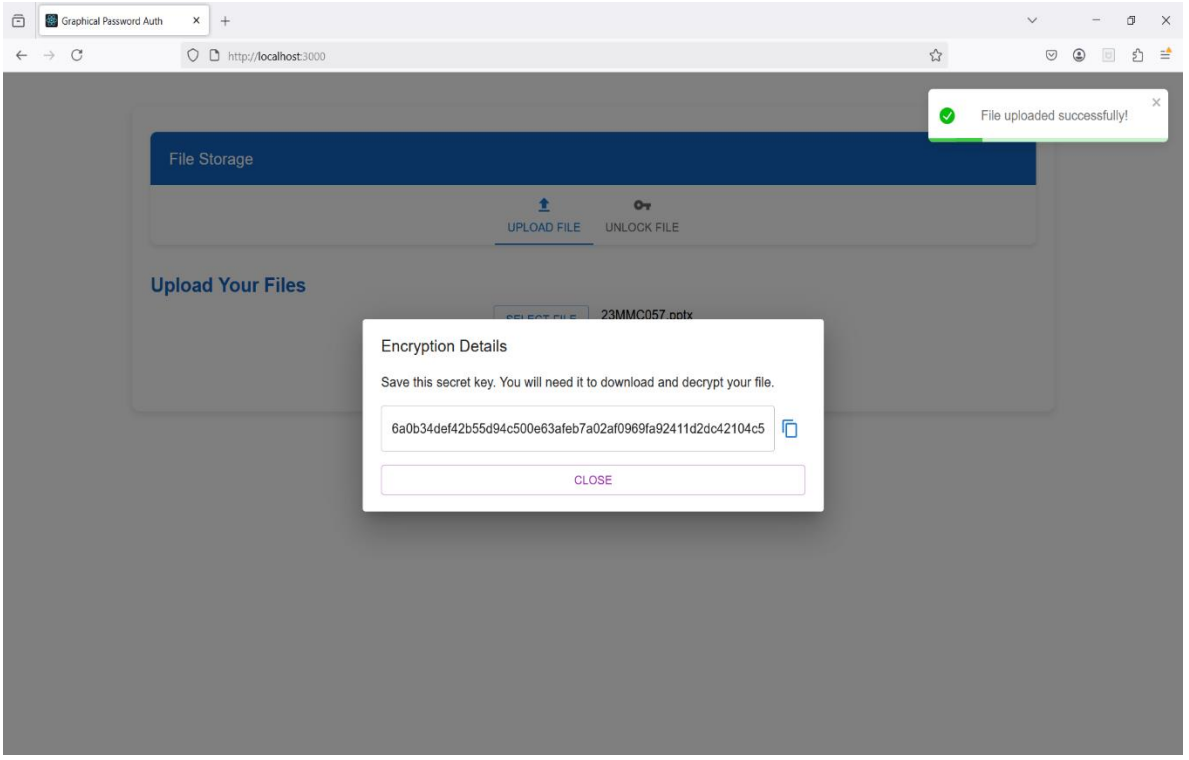



**Figure 9.2.10 File Uploaded Successfully**

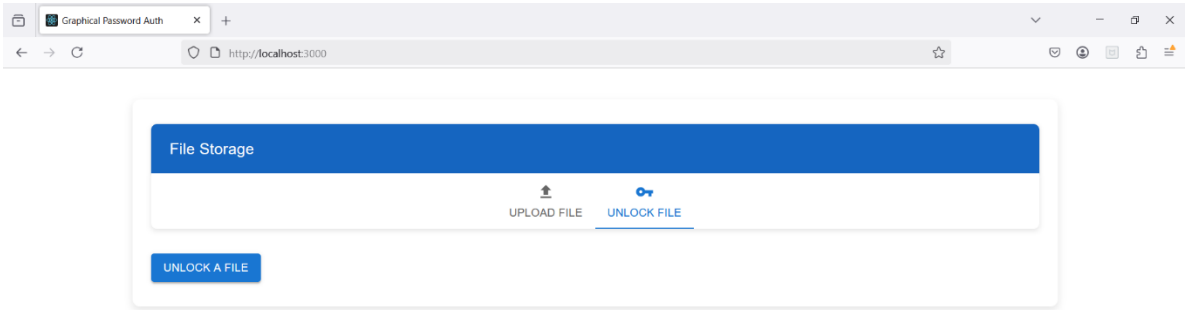



**Figure 9.2.11 File Download Page**

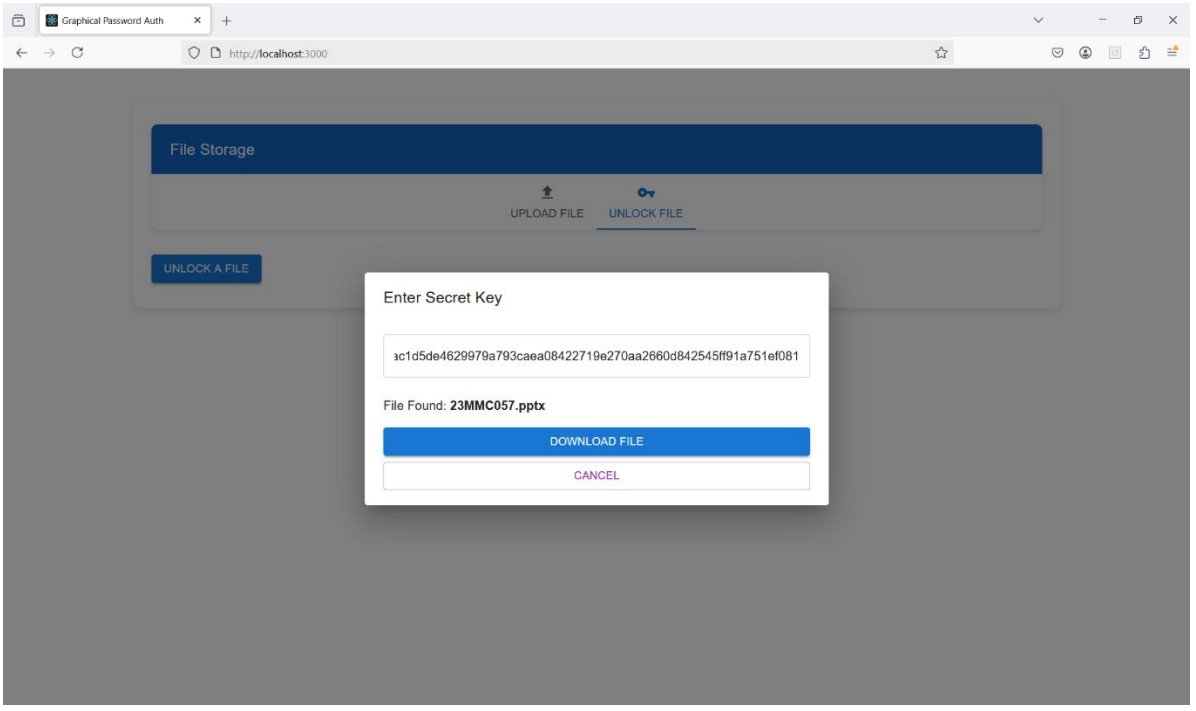



**Figure 9.2.12 File Downloaded Successfully Page**

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# CHAPTER10
# REFERENCES

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# MITIGATION OF CYBER THREADS WITH NEXT-GEN AUTHENTICATION

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**Abstract—** A lot of security primitives rely on hard mathematical problems. Security using AI hard problems is becoming a new and exciting paradigm but it has not been explored much. In this paper, we introduce a new security primitive based on hard AI problems, i.e., a new family of graphical password systems that resist large-scale online guessing attacks, while being both cost-effective and user-friendly: Next-Generation Security Based on Captcha (NGS-Captcha). It improves security against various attacks including online guessing attacks, relay attacks and with proper use of such dual-view technologies shoulder-surfing attacks. Remarkably, the only way to encounter a password in the system described is to expose it through automatic online guessing attacks, assuming it is in a search set. Furthermore, it resolves the so-called image hotspot issue in conventional graphical password systems like Pass Points that usually encourage weak password selection. For securing the functionality of the system, we have included a secure file storage module just after login. The Authenticated File System module enables authenticated users to upload and browse files on a site. The file storage system provides security of data through encryption and access controls. This added feature further enhances the security level, as it protects not only user's authentication credentials but also sensitive data. It is not a panacea, but it looks like a usable tradeoff between security and usability in the next generation of authentication. The solution is ideal for use in enterprise settings where additional user authentication and secure file access is required to bolster defences against cyber-attacks Plus, the system is integrated with file storage and retrieval options that guarantee end-to-end security. This initiative provides a smooth and secure method for authentication accelerating the move away from the status quo in today's protection against cyber threats.

***Keywords— Graphical Authentication, CAPTCHA, CaRP, Secure File Storage, Cyber Threat Mitigation.***

## I. INTRODUCTION

Conventional password-based systems cannot provide enough protection as cyber threats get in scope and complexity. Many times, users choose weak passwords or reuse credentials across multiple platforms, so allowing unwanted access and data theft. This project aims to create a system using dynamically produced CAPTCHA images in combination with graphical password techniques redefining authentication security.

The system uses CaRP—a visual password model that shows various CAPTCHA images every login session—so rendering brute force and automated attacks useless. Within these CAPTCHA images, the user's password turns into a recognition challenge adding a level of complexity machines find difficult to break. Apart from authentication, the system supports encrypted file uploads and safe downloads, accessible only to authorised users. This project thus closes the usability gap in safe systems and conforms with contemporary needs for strong authentication mechanisms. It becomes especially helpful in applications where confidential file handling and safe login are absolutely vital. Apart from authentication, this project combines a safe file storage system to let users manage and keep their private information following successful login. The module for file storage uses access control systems and encryption to stop illegal access, so guaranteeing data integrity and confidentiality.

This system provides a complete solution for reducing cyber risks and handling typical authentication vulnerabilities by combining modern authentication methods with safe file storage. The project is a good security improvement for many platforms needing safe authentication and data management since it is meant to be scalable and flexible for practical uses.

## II. RELATED RESEARCH

The evolving world of cyber threats has generated considerable scholarly and industrial study towards more secure and convenient methods of user authentication. While password-based systems are perhaps the most popular forms of authentication, they are slowly and increasingly viewed as insufficient due to their inadequacy in protecting against complex attacks such as phishing, brute-forcing, keylogging, and shoulder surfing. In order to combat these risks, a number of researchers began looking into the combination of graphical authentication, CAPTCHA, and multi-factor authentication, resulting in hybrid models such as Captcha as Graphical Passwords (CaRP).

**Graphical Passwords and Cognitive Psychology in Security Design:** A substantial amount of literature demonstrates that people remember images rather than alphanumeric strings better, which serves as the basis of graphical passwords. Cognitive science and usability studies like Biddle et al. (2012) have found that users tend to remember visual patterns, especially association with object location. This feature improves the usability of systems like CaRP, where users identify and click on certain areas of images rather than typing passwords. Other studies found that graphical password systems lessens password fatigue and input errors which improves the adoption and satisfaction rates of the system.

**Captcha as Graphical Passwords (CaRP): A Dual-Security Model:** The concept of CaRP was first introduced as a novel solution to combat automated attacks and pattern-based password guessing. Unlike static graphical passwords, CaRP dynamically generates CAPTCHA images, ensuring that each login attempt presents a unique visual challenge. Research by B. Zhu et al. (2014) demonstrated that CaRP systems resist dictionary attacks and significantly lower the chances of bots cracking authentication routines due to the unpredictable nature of the CAPTCHA generation process. Furthermore, CaRP can be extended to support different CAPTCHA types, such as object recognition and image reCAPTCHA, improving adaptability across platforms.

**Human Interaction and Authentication Design:** Usability studies on authentication focus on the balance between security and user experience. Chiasson et al. (2009) conducted research on the design and use of secure graphical passwords and found that their complex visual interfaces do offer additional security measures; however, those interfaces must be engineered for quick user engagement. In our project, the graphical authentication system allows clicks on images that depict the required patterns as intuitive images, instead of distorting CAPTCHA images, thus protecting the users from unnecessary complications.

**CAPTCHA Evolution and Resistance to Automation:** CAPTCHA technology, designed to distinguish between human users and automated bots, has significantly advanced over time. Initially, text-based CAPTCHAs were effective, but they soon fell prey to machine learning and Optical Character Recognition (OCR) methods. This prompted the move towards image-based CAPTCHAs and led to the introduction of CaRP. Recent studies in adversarial AI highlight a critical insight: while many bots can bypass traditional CAPTCHAs, they face challenges with dynamic pattern recognition tasks found in CaRP systems. This unique aspect positions CaRP as a robust solution in today's cybersecurity environment..

**Secure File Handling and Encrypted Storage Systems:** Research on secure file storage backs up the backend part of this project. Work on end-to-end encrypted storage systems (e.g., Boxcryptor Cryptomator) shows how crucial it is to encrypt files when they're stored and when they're sent. Our system follows this idea by using AES encryption and allowing file access when graphical authentication succeeds. Also, studies on audit trails and access logs point out how important it is to record all file interactions, which helps with both openness and responsibility.

**Multifactor Authentication and Adaptive Security Models :** New research also looks into the use of flexible and situation-aware multi-factor authentication systems. Studies by Komanduri et al. (2015) talk about how situation-based authentication—relying on things like what device you're using, your IP address, and your access history—can change security layers on the fly. While this project zeroes in on single-session visual authentication, it sets the stage to add more layers of security down the road.

## III. DEVELOPMENT

**Setting up the Environment:** Our secure login system starts with creating a complete web setup using the latest internet tools. We build the part you see with React.js, which is great for making pieces you can reuse and screens that change . The behind-the-scenes stuff runs on Node.js and Express.js giving us a strong base to make APIs and handle server tasks. We use MongoDB to keep user login info, CAPTCHA designs, and file details. This type of database helps us grow and get to our data fast.

**Graphical Authentication (CaRP) Implementation:** At the heart of the system is the Captcha as a Recognition Password (CaRP) model. At registration time, the system dynamically creates CAPTCHA images with numerous visual objects. The user picks certain objects or areas in the image as his/her graphical password. These point coordinates are hashed and saved safely in the database. At login time, a fresh CAPTCHA is drawn, and the user is required to duplicate his/her pattern of selection. The back end validates such inputs with the stored ones based on coordinate mapping logic and opens access only if there's an exact match.

**Captcha Generator Module:**
We've developed a custom CAPTCHA generator that creates unique visual patterns every time you load the page. This generator distorts letters, adds some noise, and even overlaps different shapes to make it tougher for bots to get through. Each CAPTCHA is designed to be one-of-a-kind, ensuring security while still being easy for humans to read. It's seamlessly integrated into the login module using JavaScript, generating everything in real time for a more engaging user experience.

**User Interface (UI) Development:** The user interface is built with React.js components, providing a sleek and responsive design. Some of the main screens include registration, a CAPTCHA-based login, secure file uploads, and a download dashboard. To maintain a consistent look across all devices, Tailwind CSS is utilized for styling. Plus, interactive elements like modals, loading spinners, and tooltips are included to enhance user feedback and accessibility..

**File Storage & Encryption Module** Once users have successfully logged in, they can dive into the secure file storage module. Files can be uploaded right through the browser interface, and as soon as they're uploaded, they're encrypted with the AES-256 encryption algorithm. The encrypted files,

along with important details like the file name, type, user ID, and upload timestamp, are safely stored in MongoDB's GridFS. Every time a file retrieval request is made, it goes through an authentication check to make sure that only the rightful users can access their data.

**Download Logging & Access Control:** To boost accountability, we log every download with timestamps, IP addresses, and user credentials. This way, we can spot any suspicious activity or unauthorized access attempts. The system employs token-based access control (JWT) to ensure session integrity, which helps prevent token hijacking or replay attacks.

**Session & Token Management:** User sessions are handled using JSON Web Tokens (JWT). When you log in, these tokens are created and they have a set expiration time, which helps ensure that access is limited to a specific period. To keep things secure, all tokens are stored in HTTP-only cookies, which helps reduce the chances of XSS attacks. When you log out, the token is removed from the client, effectively invalidating the session.

**Error Handling & Feedback**: We've put in place strong error handling on both the front and back ends. Users will receive notifications for failed CAPTCHA attempts, incorrect login details, expired sessions, and any upload problems. Our backend validation works to block any invalid or tampered requests before they can be executed, keeping the system safe from injection and logic attacks.

**Testing and Debugging**: During the development process, we carried out thorough unit and integration testing using tools like Jest and Postman. We made sure to test front-end components for their responsiveness and functionality across various browsers, while also validating backend endpoints for security and performance. To tackle any unexpected system behaviors during runtime, we relied on error logs and event trackers to help us debug effectively

## IV. WORKING PROCESS

### SECURE AUTHENTICATION ARCHITECTURE:

The Mitigation of Cyber Threads with Next-Gen Authentication system is designed with a secure and modular framework that guarantees smooth logins, safe file storage, and strong authentication. The front-end is crafted using React.js, which allows for a responsive and engaging user experience, while the back-end runs on Node.js and Express.js, managing request routing, authentication processes, and file handling. For data storage, we utilize a MongoDB database that keeps user credentials, CAPTCHA patterns, and file metadata encrypted, ensuring flexibility, speed, and scalability. At the heart of this system is the CaRP (Captcha as Recognition Password) mechanism, which merges CAPTCHA with graphical password selection. Unlike the usual static login credentials, CaRP creates visual challenges that change with each login session. This innovative approach significantly boosts resistance against automated threats like bots, brute force attacks, and shoulder surfing.

**CAPTCHA & GRAPHICAL PASSWORD SYSTEM:** When users sign up, they encounter a dynamically created CAPTCHA image filled with various characters or objects. They need to pick a specific pattern—like clicking on three characters in a particular order—which then becomes their graphical password. These click coordinates are carefully mapped, encrypted, and securely saved in the database. When it's time to log in, a fresh CAPTCHA image is generated on the spot, and users must identify and click the same pattern again. The system then checks the coordinates against what's stored using a tolerance-based matching algorithm. If everything lines up, the user is authenticated and granted access. This approach guarantees that the CAPTCHA is unique for each session, making it tough for bots to replicate or for automated attacks to succeed.

### FILE ENCRYPTION AND STORAGE

Once you're logged in, users can easily access a secure dashboard where they can upload or download files. Any files you upload are automatically encrypted with the AES-256 algorithm, which is one of the most robust symmetric encryption methods out there. This encryption takes place on the server side before the file is stored in the MongoDB GridFS system. Along with the file itself, we also keep track of important details like the file type, size, timestamp, and user ID. When it's time to retrieve a file, the system decrypts it in real-time and asks the user for confirmation before allowing the download. This way, we make sure that only authorized and verified users can access the stored data

### SESSION & TOKEN MANAGEMENT

Session control is managed through JWT (JSON Web Tokens) to keep user authentication secure across different routes. When a user logs in successfully, a token is created and saved in an HTTP-only cookie, which helps shield it from client-side attacks. These sessions are time-sensitive, and the token will expire after a period of inactivity, leading to an automatic logout. When a user logs out, the token is invalidated, and any session traces are cleared, ensuring that access to the system remains secure and temporary.

### SECURITY LAYERS & VALIDATION

To keep up with the ever-changing landscape of cyber threats, the system is built with several layers of security that strengthen both the authentication process and how files are handled. One of the key defenses is rate limiting, which controls how many login attempts can be made from a single IP address within a certain time period. This approach effectively reduces the risk of brute-force and dictionary attacks by stopping automated scripts from quickly guessing passwords. In addition to rate limiting, there's a CAPTCHA refresh feature that lets users request a new visual challenge during login, making sure that security and accessibility go hand in hand, especially when the original CAPTCHA is hard to read. The system also uses input sanitization techniques for all input fields and API endpoints. This means that any data provided by users is cleaned and validated before it reaches the backend services, helping to neutralize threats like SQL injection, cross-site scripting (XSS), and code injection attacks. By enforcing strict content-type checks and escaping special characters, the application guarantees that all inputs meet the expected formats and behaviors. Integrated

throughout the back-end infrastructure are comprehensive error handling modules. These modules are crafted to capture and log any anomalies without revealing internal logic or stack traces to the end user. This way, malicious actors can't gain insights into the system's architecture or take advantage of unhandled exceptions. Errors are logged with timestamps and contextual metadata, allowing developers and administrators to review incidents and respond proactively to any potential vulnerabilities. Additionally, validation pipelines are in place for all sensitive interactions within the system, especially for file uploads and downloads. These pipelines check file types, scan for any executable or harmful content, enforce size limits, and ensure that only authenticated users can access the relevant resources. All file transactions are carefully monitored to maintain security and integrity.

**INTEGRATION WITH WEB TECHNOLOGIES:**

**Front-End Integration**: The front end interacts with the server through RESTful APIs, enabling smooth asynchronous communication. CAPTCHA images are retrieved from a secure endpoint, and all responses are rendered dynamically.

**Back-End Operations**: The back end guarantees that authentication, encryption, and database interactions happen securely and efficiently. Our file handling services are fine-tuned to manage various file types and sizes without slowing down the system. Cloud Compatibility: Thanks to the modular design of the application, it can easily integrate with cloud platforms like AWS S3 or Google Cloud for secure cloud storage and scalability.

**FEATURES AND USER EXPERIENCE:** The system is built with a strong focus on security and user-friendly design, making sure that users have a smooth and intuitive experience. One standout feature is the graphical login flow, which swaps out traditional text-based passwords for an image-based authentication method. This not only boosts security but also makes it easier for users, as they engage with visual patterns that are simpler to remember and less susceptible to automated attacks. The file management interface boasts a clean and responsive layout, allowing users to easily upload, view, and download files in a secure environment. It's designed to be straightforward and functional, so even those who aren't tech-savvy can navigate file operations without any hassle. To promote accountability and traceability, the system has a download logging feature that records every file download, complete with timestamps, file IDs, and user credentials. This creates an audit trail that can be reviewed for security or administrative needs, adding a layer of transparency to file access. Moreover, there's a refreshable CAPTCHA feature on the login screen, which lets users request a new CAPTCHA image if the current one is hard to read. This ensures that everyone can access the system easily, enhances the login experience, and keeps the authentication process secure. All these features work together to create a secure, efficient, and user-friendly system, striking a perfect balance between top-notch protection and a smooth, engaging user experience**.**

**DEVELOPMENT TOOLS & TECHNOLOGIES:** The Mitigating Cyber Threats with Next-Gen Authentication system is built on a cutting-edge full-stack technology suite designed to deliver top-notch security, performance, and scalability. For the front end, we're using React.js, a well-loved JavaScript library that makes it easy to create dynamic and responsive user interfaces thanks to its component-based architecture. On the back end, we rely on Node.js paired with Express.js to handle the server logic and API routing, ensuring smooth communication between the client interface and server processes. When it comes to storing data, we've chosen MongoDB as our database solution. It offers great flexibility for managing user credentials, session data, and encrypted file metadata through its document-based structure. To keep user sessions secure, we implement JSON Web Tokens (JWT), which allow for stateless authentication and time-limited access control. To safeguard user files, we incorporate AES-256 encryption, a robust symmetric encryption algorithm that's well-regarded for its ability to protect sensitive data during both storage and transmission. We also add extra security layers with libraries like Helmet.js, which secures HTTP headers, and Bcrypt.js, used for hashing sensitive user credentials such as passwords. For testing and validation, we utilize tools like Postman to check API endpoints and data flows, while Jest is our go-to for unit and integration testing across various

components. All these technologies come together to create a cohesive and powerful development environment that ensures the secure and efficient implementation of the system.

## V. CONCLUSION

The Mitigating Cyber Threats with Next-Gen Authentication project isn't just about improving traditional security measures; it's about rethinking how authentication can adapt to the challenges we face in today's digital world. With data breaches, identity theft, and cyber-attacks becoming more sophisticated and common, this initiative offers a forward-looking solution that swaps out vulnerable text-based logins for dynamic, image-based graphical passwords, all while incorporating CAPTCHA technology. By blending cognitive science with security engineering, this system allows users to engage with authentication in a way that feels more intuitive and visually appealing. The use of CaRP (Captcha as Recognition Password) not only helps to block automated attacks but also adds an element of unpredictability and uniqueness to each login attempt—something you don't often see in traditional systems. Plus, the smooth integration of secure file storage and encryption protocols guarantees that sensitive information stays protected from unauthorized access throughout the entire user experience. Moreover, this project highlights the incredible potential of secure-by-design principles. It shows how cybersecurity can be both strong and user-friendly by combining solid back-end encryption with an accessible front-end design. As our digital environments continue to grow, the need for adaptable, intelligent, and user-focused security models will only become more pressing. In summary, Mitigating Cyber Threats with Next-Gen Authentication sets a new standard for secure access control by focusing on both usability and security. It represents a forward-thinking approach to authentication—not just as a barrier, but as a smart, responsive gateway to secure digital spaces. This system not only protects against current threats but also paves the way for future innovations, ultimately creating a safer, more reliable, and trustworthy online experience

## VI- REFERENCES


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