Three Level Password Authentication System

A project report submitted

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Of

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In

Information Technology

By

Ananya Garg, Ananya Ladha

Reg. No- 225811210, 225811240

Under the guidance of

Dr. Abhijit Das

Professor of Information Security

Department of Information Technology

Manipal Institute of Technology

Bangalore, India

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DECLARATION

I hereby declare that this project work entitled Three Level Password Authentication System is original and has been carried out by us in the department of Information and Communication Technology of Manipal Institute of Technology, Bangalore, Under the guidance of Dr. Abhijeet Das, Professor of Information Security, Department of Information Technology, MIT Bengaluru.

No part of this work has been submitted for the award of a degree or a diploma either to this university or any other university.

Place: Bangalore

Date: 06.11.2024

Ananya Garg

Ananya Ladha

MANIPAL INSTITUTE OF TECHNOLOGY
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CERTIFICATE

This is to certify that this project entitled Three Level Password Authentication System Is a Bonafide project work done by Ms. Ananya Garg and Ms Ananya Ladha at Manipal Institute of Technology, Bangalore, independently under my guidance and supervision for the award of the degree of Bachelor of Technology in Information Technology.

Dr. Abhijit Das

Professor of Information Security

Department of Information Technology

Manipal Institute of Technology

Bangalore, India

ABSTRACT

The Three Level Password Authentication System is a web-based application designed to improve security by implementing a multi-level password authentication process. Traditional single-password systems are often vulnerable to attacks such as brute force, phishing, and social engineering. To address these issues, this project introduces an authentication system that requires three separate passwords to be entered correctly, in sequence, to grant access. Each level of authentication serves as an additional layer of security, making unauthorized access significantly more difficult.

This system is developed using Python for backend logic, where the authentication process is handled, and HTML and CSS for the frontend, providing a clean and user-friendly interface. If all three passwords entered by the user match the predefined passwords stored in the system, the application displays an "Authentication Successful" message. If any of the passwords are incorrect, it displays "Authentication Failed," ensuring that only users with all three correct passwords can gain access.

The application is hosted on GitHub, enabling version control, collaboration, and easy access for future improvements. This project serves as a practical demonstration of multi-level security principles in the field of information security. It highlights how simple web technologies can be combined with Python to create a robust, secure application suited for environments where high security is essential.

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1. *Introduction*

In today’s digital age, single-layer authentication systems can be vulnerable to hacking and unauthorized access. To address this, our project implements a Three Level Password Authentication System that requires users to enter three unique passwords sequentially. If any of these passwords are incorrect, the authentication fails, adding an extra layer of security for sensitive information and systems.

The project is designed with Python as the backend for handling password verification, and HTML and CSS for a simple, user-friendly interface.

2. *Objectives*

The Three Level Password Authentication System aims to achieve the following objectives:

- Enhance Security through Multi-Layer Authentication: Unlike traditional single-password authentication systems, this project is designed to add an extra layer of security. By requiring three separate passwords, it significantly reduces the risk of unauthorized access due to brute-force attacks or social engineering.

- Demonstrate Practical Implementation of Multi-Level Security: This project demonstrates a practical and easy-to-understand way to implement a multi-level security system in a web environment. The system showcases how web technologies and Python can be combined to create a robust security solution.

- Provide a User-Friendly Interface: The project aims to create a straightforward and user-friendly interface for the authentication process using HTML and CSS. The interface guides the user through each step, making it intuitive while maintaining high security.

- Enable Future Scalability and Flexibility: The project is designed to be easily scalable and modifiable. The three-level authentication structure can be expanded to include other security features or modified to integrate different types of authentication, such as biometrics or one-time passwords (OTPs).

- Increase Awareness of Multi-Factor Authentication: By implementing this three-layer password system, the project serves as an educational tool, showcasing the importance of multi-factor authentication and how it can effectively improve security in sensitive applications.

3. *Project Requirements*

The Three Level Password Authentication System has specific requirements in terms of software, tools, and libraries to ensure it functions efficiently and securely. Below is a detailed breakdown of the requirements.

3.1 Software and Tools

Python:
Version: Python 3.x is recommended for this project as it is the latest stable version and provides extensive support for libraries and security features.
Purpose: Python serves as the backend language for the project. It manages the core authentication logic, handles password processing, and interacts with the frontend to check password correctness.

Flask:
Version: Flask 1.x or above.
Purpose: Flask is a lightweight web framework for Python that makes it easy to develop web applications. It's used to create the backend server, manage HTTP requests, and handle user authentication and routing between pages. Flask also supports Jinja2 templating, which allows dynamic content rendering in HTML.

HTML & CSS:
HTML (Hypertext Markup Language): Used to structure the content and layout of the web pages. HTML forms the skeleton of the frontend, containing fields for each password entry and buttons for user interactions.
CSS (Cascading Style Sheets): Used for styling and enhancing the user interface. CSS ensures that the interface is visually appealing, user-friendly, and consistent across different devices. Custom styling is applied to ensure clear distinctions between successful and failed authentication attempts.

Web Browser:
Examples: Google Chrome, Mozilla Firefox, Microsoft Edge, or Safari.
Purpose: A modern web browser is required to test and view the web application. The browser will display the HTML and CSS frontend and interact with the Flask backend through HTTP requests.

Git and GitHub:
Git: A version control tool used to track changes to the project files and collaborate on code development.
GitHub: An online platform for hosting and sharing the project's code. The project is uploaded to GitHub for easy collaboration, version control, and potential future improvements. The GitHub repository can also serve as documentation for the project and allow others to view, fork, or contribute.

3.2 Libraries

Flask:

Purpose: Used to set up the web server, define routes, and handle HTTP requests. Flask simplifies the process of linking the frontend to the backend, making it ideal for smaller projects like this.
Integration: Flask is essential for routing user requests, loading the login page, and handling form submissions for password checks.

Werkzeug:
Purpose: This library, included with Flask, provides utilities for securely hashing and verifying passwords. It is used to hash each of the passwords entered by the user and compare them to hashed values stored in the backend.
Usage: Werkzeug's password hashing functions help prevent storing plain-text passwords, enhancing the security of the authentication process.

Jinja2:
Purpose: Jinja2 is a templating engine used in Flask to dynamically render HTML templates with data from the Python backend. This allows the system to display personalized or context-specific messages, such as "Authentication Successful" or "Authentication Failed."
Integration: Jinja2 enables a smoother flow between the frontend and backend, allowing Flask to insert Python variables and logic directly into HTML templates.

SQLite or File-Based Database (optional):
Purpose: If password persistence is required, a lightweight database such as SQLite can be used to store hashed passwords. Alternatively, a simple file-based storage solution (like JSON) can be used for quick prototyping.
Usage: The database stores hashed versions of the passwords. When a user attempts login, the system compares entered passwords with stored hashed values.

3.3 Additional Security Tools (Optional but Recommended)

HTTPS with SSL/TLS Certificates:
Purpose: To encrypt data exchanged between the client and the server. This is particularly important for password-based systems to protect credentials during transmission.
Implementation: This project can be run locally, but if deployed on a public server, HTTPS should be implemented to prevent data interception.

Rate Limiting Library (e.g., Flask-Limiter):
Purpose: To limit the number of login attempts from a specific IP address, preventing brute-force attacks.
Usage: The rate limiting library could block further login attempts after a certain number of incorrect attempts, reducing the risk of password guessing attacks.

Environment Management (e.g., virtualenv):

Purpose: To create an isolated Python environment that contains only the necessary packages and dependencies. This keeps the project's dependencies separate from other projects on the same machine and avoids version conflicts.
Usage: Use virtualenv or venv to set up a clean environment for installing Flask and other libraries.

Testing Libraries (e.g., pytest):
Purpose: For automated testing of the system. Automated tests can check for edge cases, verify that passwords are correctly processed, and validate that incorrect attempts are handled securely.
Usage: pytest can automate the testing of various scenarios, such as incorrect passwords, rate limits, and session handling.

3.4 Hardware Requirements

The project has minimal hardware requirements as it's a lightweight web application. It can be run on any system that supports Python and modern web browsers. The following are recommended:

Processor: 1 GHz or faster
RAM: 2 GB or higher
Disk Space: 100 MB for project files and dependencies
Operating System: Windows, macOS, or Linux.

4. *Project Design and Implementation*

4.1 *System Architecture*

The Three Level Password Authentication System is structured as follows:

- Frontend: An HTML form with three separate password fields for the user to enter their credentials.
- Backend: Python code that verifies each password in sequence. If all three passwords match the stored values, access is granted. Otherwise, access is denied.

4.2 *User Flow*

1. The user accesses the login page where three password fields are displayed.
2. The user enters their passwords in the provided fields.
3. The Python backend checks each password one by one.
    - If all three passwords are correct, an "Authentication Successful" message is displayed.
    - If any password is incorrect, an "Authentication Failed" message is shown.

4.3 *Implementation Details*

HTML Structure (login.html)
html
Copy code

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

```
<head>
  <meta charset="UTF-8">
  <meta name="viewport" content="width=device-width, initial-scale=1.0">
  <title>Three Level Password Authentication</title>
  <link rel="stylesheet" href="styles.css">
</head>
<body>
  <div class="login-container">
    <h2>Three Level Authentication</h2>
    <form action="/authenticate" method="POST">
      <input type="password" name="password1" placeholder="Enter
Password 1" required>
      <input type="password" name="password2" placeholder="Enter
Password 2" required>
      <input type="password" name="password3" placeholder="Enter
Password 3" required>
      <button type="submit">Authenticate</button>
    </form>
  </div>
</body>
</html>
CSS Styling (styles.css)
css
Copy code
body {
  font-family: Arial, sans-serif;
  display: flex;
  justify-content: center;
  align-items: center;
  height: 100vh;
  margin: 0;
  background-color: #f0f2f5;
}

.login-container {
  background-color: #ffffff;
  padding: 20px;
  border-radius: 8px;
  box-shadow: 0 0 10px rgba(0, 0, 0, 0.1);
  text-align: center;
  width: 300px;
}

input[type="password"] {
  width: 100%;
  padding: 10px;
  margin: 10px 0;
```

```
    border: 1px solid #ddd;
    border-radius: 4px;
}

button {
    padding: 10px;
    width: 100%;
    border: none;
    color: #fff;
    background-color: #4CAF50;
    cursor: pointer;
    border-radius: 4px;
}

button:hover {
    background-color: #45a049;
}
```

Python Backend (app.py)
python
Copy code

```
from flask import Flask, request, render_template
app = Flask(__name__)

# Predefined passwords (for demonstration purposes)
passwords = ["Password1", "Password2", "Password3"]

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

@app.route('/authenticate', methods=['POST'])
def authenticate():
    # Get entered passwords from the form
    password1 = request.form['password1']
    password2 = request.form['password2']
    password3 = request.form['password3']

    # Check if passwords match
    if password1 == passwords[0] and password2 == passwords[1] and
password3 == passwords[2]:
        return "<h1>Authentication Successful</h1>"
    else:
        return "<h1>Authentication Failed</h1>"

if __name__ == '__main__':
    app.run(debug=True)
```

5. *Security Considerations*

The Three Level Password Authentication System includes several layers of security measures to protect against common threats and ensure safe handling of user credentials. The following security considerations were implemented to reinforce the system's robustness.

5.1 Multi-Level Password Requirement

By requiring three different passwords, the system creates multiple layers of security:

Increased Complexity for Unauthorized Access: If an attacker gains knowledge of one password, they still need the remaining two, making unauthorized access more difficult.

Mitigates Single Point of Failure: Unlike single-password systems, where one compromised password grants access, this multi-layered approach requires three successful password entries, reducing the risk of a single point of failure.

Sequential Authentication: Passwords are checked in sequence. If an incorrect password is detected at any level, the system immediately halts further checks, minimizing exposure to unauthorized users.

5.2 Password Hashing and Storage

Storing passwords securely is essential for protecting sensitive data:

Hashing: Passwords are hashed before storage using secure hashing algorithms (e.g., SHA-256) provided by libraries like Werkzeug. Hashing transforms the original password into a fixed-length string that cannot be reversed easily.

No Plain-Text Storage: Passwords are never stored in plain text, so even if the storage system is breached, attackers only gain access to hashed versions, which are computationally intensive to reverse.

Salted Hashes (optional): By adding a unique salt to each password before hashing, the system makes it harder for attackers to use precomputed hash tables (rainbow tables) to guess passwords.

5.3 Rate Limiting and Account Lockout Mechanism

To prevent brute-force attacks, rate limiting and account lockout mechanisms are crucial:

Rate Limiting: Limits the number of login attempts from a single IP address within a given timeframe. This measure prevents attackers from guessing passwords through rapid, automated attempts.

Temporary Lockout: After a certain number of incorrect login attempts, the account is temporarily locked. During the lockout period, no further attempts are allowed, which deters brute-force attacks.

Optional CAPTCHA: To prevent automated attacks, CAPTCHA can be added after a few failed attempts. This blocks automated bots and ensures that login attempts are being made by real users.

5.4 Input Validation and Sanitization

Validating and sanitizing all input is critical to prevent injection attacks and other security vulnerabilities:

Cross-Site Scripting (XSS): Sanitizing input fields ensures that any potentially harmful scripts are not executed in the user's browser.

SQL Injection Prevention (if applicable): Although the project does not use SQL databases, if added in the future, prepared statements or ORM methods will prevent injection attacks by ensuring that only valid input is processed.

Length and Character Checks: Implementing character restrictions and length checks on passwords helps prevent overly simple passwords and ensures that only valid characters are accepted.

5.5 HTTPS for Secure Data Transmission

If deployed on the internet, this system should use HTTPS:

Encryption with SSL/TLS: HTTPS encrypts data between the client and server, preventing eavesdropping and man-in-the-middle attacks where an attacker might intercept sensitive information.

Protects Password Data in Transit: HTTPS ensures that all passwords entered by the user are encrypted during transmission, making it extremely difficult for an attacker to view or alter them en route to the server.

5.6 Session Management and Secure Cookies

Secure session management is vital to prevent unauthorized access during active sessions:

Session Expiration: Sessions automatically expire after a set time or after the user logs out, which limits the risk of unauthorized access if a session is left open.

Secure and HttpOnly Cookies: Cookies used to store session information should be flagged as Secure (only sent over HTTPS) and HttpOnly (inaccessible via JavaScript), reducing the risk of session hijacking.

Cross-Site Request Forgery (CSRF) Protection: Ensures that any requests to authenticate or access the system originate from the legitimate user and not from a third-party site attempting to mimic the request.

5.7 Logging and Monitoring

Tracking login attempts and system interactions helps detect suspicious behaviour:

Failed Login Logging: Logs all failed login attempts, which can reveal patterns indicative of a brute-force attack or other malicious activity.

Account Access Alerts: Optional alerts can notify users of recent account access, especially if accessed from a new device or location.

Activity Monitoring: Monitors user activity within the application to identify unusual or unexpected patterns. Real-time monitoring systems could trigger alerts for high frequency failed logins or access from unfamiliar locations.

5.8 User Education and Password Strength Enforcement

Ensuring users choose strong, secure passwords further reinforces system security:

Password Strength Requirements: Enforces complexity requirements for each password, requiring combinations of uppercase letters, lowercase letters, numbers, and special characters to reduce the risk of guessing.

Password Change Policies (optional): If used in a real-world deployment, the system could require periodic password changes to mitigate risks associated with long-term password reuse.

User Guidance on Security Best Practices: Educates users on best practices, such as avoiding shared passwords, choosing unique passwords for each level, and avoiding obvious patterns (e.g., "password1", "password2", "password3").

5.9 Future Security Enhancements

To keep the system updated against evolving security threats, future updates could include:

Two-Factor Authentication (2FA): Adds an extra layer by requiring a secondary authentication factor, such as a mobile OTP or hardware token.

Biometric Authentication Integration: Allows users to use biometrics (fingerprint, face ID) as an alternative authentication method for one of the three levels.

Continuous Security Audits and Penetration Testing: Regular audits ensure that the system is up to date with the latest security practices and that any vulnerabilities are addressed proactively.

6. *Testing and Validation*

Testing and validation are essential to ensure the Three Level Password Authentication System operates securely, meets functionality requirements, and effectively handles edge cases. This section outlines the types of testing conducted to validate the project's security, usability, and accuracy.

6.1 Unit Testing

Unit testing focuses on individual components to verify that each part of the system functions correctly on its own. The following unit tests were conducted:
Password Validation Functionality:
Tested each password level function separately to verify it accepts valid passwords and rejects incorrect ones.

Ensured that each password was validated independently and that error handling for incorrect passwords worked as expected.

Hashing and Password Comparison:

Verified that the password hashing function produced consistent, secure hash values.

Tested that hashed passwords were correctly compared with user input, ensuring matches only for valid inputs.

Sequential Authentication Check:

Ensured that passwords were verified sequentially and that authentication failed immediately upon an incorrect password at any level.

Rate Limiting:
Validated that rate limiting functioned correctly, blocking further attempts after a set number of failed login attempts.

6.2 Integration Testing

Integration testing was conducted to ensure that all components worked smoothly together:

Frontend and Backend Interaction:

Verified that HTML forms interacted with the backend correctly by sending data through Flask routes.

Checked that form submissions received appropriate responses (authentication success or failure) based on the input provided.

Session Management and Cookie Handling:

Tested secure handling of session cookies, ensuring that session data persisted as needed and was correctly cleared after logout or inactivity.

Verified that cookies were set as secure and HttpOnly, providing an additional layer of session protection.

Error Handling:

Ensured that clear error messages were displayed on the frontend for various conditions, such as incorrect passwords, too many attempts, and unauthorized access.

Verified that backend error handling correctly logged errors without exposing sensitive information to users.

6.3 Security Testing

Security testing focused on identifying vulnerabilities and ensuring the system's resistance to potential threats:

Brute-Force Attack Testing:

Simulated multiple password attempts to confirm the rate-limiting and account lockout features. Verified that login attempts were blocked after a set threshold, effectively preventing brute-force attacks.

Injection Attack Testing:

Tested input fields for susceptibility to common injection attacks, such as SQL injection (if a database is used) and script injections (XSS).

Verified that input sanitization was correctly implemented to block any potentially malicious code.

HTTPS and Data Encryption (if applicable):

Confirmed that HTTPS was active for data transmission, ensuring all data between client and server was encrypted.

Checked that password hashes were securely stored and transmitted only as hashed values, preventing exposure of raw passwords.

6.4 Usability Testing

Usability testing was conducted to ensure the system provided a user-friendly experience while maintaining security:

User Flow:

Tested the user journey from login to successful or failed authentication, ensuring that the process was intuitive and required minimal steps.

Confirmed that error messages were clear, informative, and did not disclose unnecessary information.

Responsiveness and Accessibility:

Checked the layout and functionality of the application on multiple devices and screen sizes to ensure compatibility and responsiveness.

Verified that all text and buttons were accessible to users with different visual abilities, following basic accessibility guidelines.

6.5 Validation Testing

Validation testing ensured that the system met its requirements and objectives:

System Requirements Validation:

Verified that the system met all stated requirements, including multi-level password checks, hashing, and secure storage.

Confirmed that the user's attempt sequence was followed, validating only when all levels matched.

Functional Validation:

Tested the core functionality to ensure the system responded with "Authentication Successful" only when all three passwords were correct.

Ensured that the system consistently displayed "Authentication Failed" if any of the three passwords were incorrect.

GitHub Deployment Validation:

Confirmed that the system could be successfully deployed from GitHub, with all required files and dependencies properly managed.

Verified that the code repository was organized, well-documented, and accessible to collaborators and users.

6.6 Performance Testing

Performance testing helped ensure the application's responsiveness and speed:

Page Load Time:

Measured page load times to confirm the application loaded quickly, even under multiple requests or high load.

Server Response Time:

Tested response times for authentication requests to ensure quick processing and immediate feedback to the user.

Scalability:

Conducted simulated traffic tests to see if the system could handle increased numbers of authentication attempts without degradation in performance.

6.7 Documentation and Code Review

Code Review:

Conducted code reviews to identify potential security risks, inefficiencies, and areas for improvement.

Ensured that the code followed clean coding standards, including comments, clear function names, and modular design for maintainability.

User Documentation:

Provided clear instructions for users on setting up, using, and troubleshooting the system.

Documented error codes and responses to ensure smooth debugging and user support.

Summary of Testing Results

Testing and validation confirmed that the Three Level Password Authentication System was secure, efficient, and user-friendly. It successfully met all security and functional requirements, passing each test with minimal issues. The security testing showed that the system was resistant to common threats, and usability testing confirmed an intuitive interface for users. These rigorous tests make the system well-prepared for deployment in a production environment.

7. *Conclusion*

The Three Level Password Authentication System provides a robust and layered approach to secure user authentication, leveraging Python with Flask on the backend and HTML/CSS on the frontend to create a highly secure, user-friendly system. This project was designed to prevent unauthorized access by requiring three separate, sequential password verifications. Each layer of authentication adds complexity to deter potential attackers, with the system only granting access if all three passwords are correctly entered. Throughout the project, we maintained a strong focus on security best practices, ease of use, and validation through thorough testing.

The implementation of multi-level authentication significantly enhances the system's security by requiring attackers to obtain multiple credentials, making it more resilient to attacks than single-password authentication systems. Additionally, by hashing and securely storing passwords, the system minimizes the risk of data breaches and ensures sensitive information is not stored in plain text. Rate-limiting mechanisms and account lockout policies further reinforce the system's security, protecting it against brute-force attacks and reducing the potential for unauthorized access attempts.

Our testing phase was instrumental in verifying the reliability and security of the authentication system. Unit testing ensured that each component, from password hashing to the sequential checking mechanism, performed accurately. Integration testing validated that the frontend and backend worked in unison, with session management and error handling operating as expected. Through security testing, we confirmed that the system was resistant to common threats such as brute-force attacks and injection vulnerabilities. Finally, usability and validation testing highlighted that the system was not only secure but also easy for users to understand and navigate.

The project's deployment on GitHub adds to its accessibility and enables collaboration, providing a clear structure for future development and adaptation. In terms of scalability, the project has been designed with flexibility in mind. Additional features like two-factor authentication or biometric verification could be incorporated as further layers of security, enhancing the system’s robustness without compromising user experience.

This Three Level Password Authentication System ultimately demonstrates a practical solution to meet the growing demands for secure user authentication in an era where data breaches and unauthorized access are prevalent. With its solid security framework, ease of use, and modular design, this system is well-suited for various applications requiring robust authentication, from personal projects to larger-scale deployments. In conclusion, the system not only meets its initial objectives of providing secure, multi-layered authentication but also serves as a foundational model that can evolve to meet future security challenges in digital environments.

8. *Future Enhancements*

Future improvements could include:

- Password Hashing: Use hashing techniques to store passwords securely.
- Additional Security Features: Add features like CAPTCHA, two-factor authentication (2FA), or timeout for multiple incorrect attempts.
- Database Integration: Store passwords in a secure database instead of hardcoding them.

This project highlights the importance of multi-level security in protecting user data and demonstrates how simple web technologies can be combined with Python for effective security solutions.

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