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"Graphical Password Authentication using Blockchain"

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Abstract: ***This paper proposes a novel approach to authentication by integrating graphical passwords with blockchain technology. By storing authentication data on the blockchain, we aim to enhance security and accountability. Our system offers tamper-proof records and decentralized authentication, contributing to improved security in digital systems.***
Keywords: Graphical Password Authentication, Blockchain Technology, Security, Decentralization

I. INTRODUCTION

Authentication is a critical aspect of securing digital systems, vital for safeguarding against unauthorized access and potential breaches of sensitive information. While conventional text-based passwords have historically been the go-to method of authentication, they are vulnerable to a range of security threats including phishing attacks, dictionary attacks, and keyloggers. In light of these challenges, graphical password authentication systems have emerged as a viable alternative, utilizing users' visual memory to generate and recall passwords. Nevertheless, these systems are not impervious to their own set of vulnerabilities, including risks such as shoulder surfing and social engineering.

To address these shortcomings, this research proposes a novel authentication approach that combines graphical password authentication with blockchain technology. Blockchain, originally designed as a decentralized and tamper-proof ledger system for cryptocurrencies like Bitcoin, offers inherent security features that can significantly enhance the authentication process. By storing authentication data on the blockchain, our proposed system aims to provide a secure, transparent, and decentralized authentication framework. This integration not only enhances the security and accountability of the authentication process but also mitigates the risks associated with traditional password-based authentication methods.

In this paper, we present the architecture and implementation details of our proposed system, along with an analysis of its security implications and potential applications in real-world scenarios. Through simulations and experiments, we demonstrate the effectiveness of our approach in addressing common authentication vulnerabilities while maintaining user convenience and usability, for better understanding of the concept let's take a look at below fig

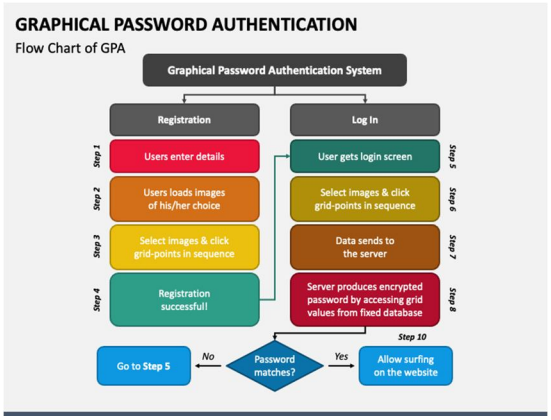


Fig 1 . Flowchart of GPA

II. RELATED WORK

In recent years, the integration of graphical password authentication with blockchain technology has garnered significant attention due to its potential to enhance security in various applications. Several studies have explored different aspects of this approach, aiming to address the limitations of traditional text-based passwords and improve user authentication methods.

Yan et al. conducted empirical research on the memorability and security of passwords, highlighting the need for more robust authentication mechanisms [1]. Wang and Zheng provided a comprehensive review of graphical password authentication techniques and implementations, emphasizing the importance of usability and security considerations [2]. Nakamoto's seminal work on blockchain technology introduced the concept of a decentralized digital ledger, which has since revolutionized various industries [3]. Swan's book "Blockchain: Blueprint for a New Economy" offers insights into the architecture and potential applications of blockchain technology [4].

Alabdulatif and Jones proposed a method to enhance password security using blockchain technology, illustrating the potential synergy between decentralized ledgers and authentication mechanisms [5]. Raza et al. presented a novel approach for secure authentication using graphical passwords and blockchain, demonstrating the feasibility of integrating these two technologies [6]. Alenezi and Heidari introduced a blockchain-based authentication framework using graphical passwords for IoT devices, highlighting the scalability and security benefits of distributed ledger technology [7]. Jiang et al. developed a blockchain-based authentication scheme using graphical passwords for secure IoT environments, addressing the challenges of authentication in interconnected systems [8]. Wang et al. proposed a blockchain-based authentication scheme using graphical passwords for secure access control in cloud environments [9].

These studies collectively contribute to the growing body of research on graphical password authentication with blockchain technology, offering insights into its potential applications, security enhancements, and usability considerations.

III. METHODOLOGY

The proposed authentication method is primarily designed for web applications. Upon opening the application, users are greeted with a welcome page offering two options: login and signup, enabling them to access the contents of the web application. New users must sign up to register successfully and gain access to the app's content. During the signup process, users are prompted to provide personal details such as first name, last name, and a valid email address. Additionally, users can select a unique username, which may include alphanumeric characters. If the chosen username is unavailable, users must select a different one. Upon successful validation of user details, an alphanumeric password is sent to the user's email address by the administrator. User registration details are securely stored in the backend, managed by IPFS. Users can utilize this password for subsequent logins and have the option to change it as desired. Following text password registration, users are presented with a 3x3 matrix of images, from which they must select three images as part of the signup process. This registration step concludes the signup process, enabling users to successfully register for the application.

Users can sign in at their convenience using their account credentials. The initial authentication phase involves entering a user ID and alphanumeric password. Five attempts are allowed for text password authentication; upon exhaustion, users can reset their password via the "forgot password" option by providing their email address.

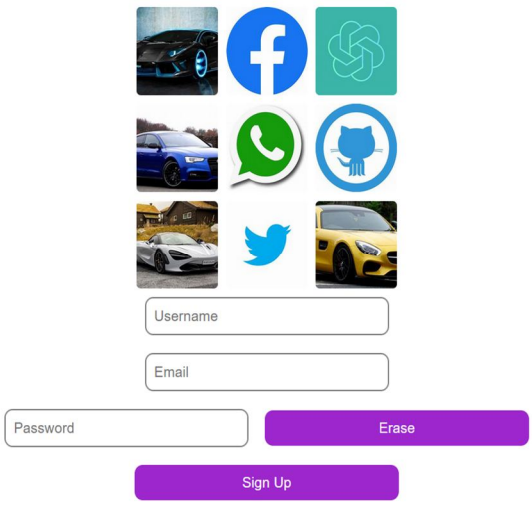


Fig 2. 3*3 matrix of images

Following text password authentication, users proceed to a second security level: graphical password authentication. This involves selecting images from a 3x3 matrix, akin to their registration phase. Once users successfully match the images, regardless of sequence, they gain access to the system as shown in below fig

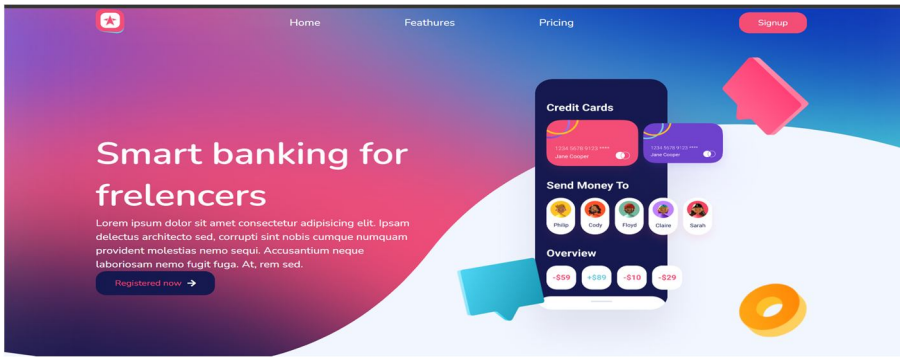


Fig 3. Example of a system

A. User Enrollment: A Secure Foundation

1) Streamlined Registration - Users establish their accounts by providing a username, email address, and crafting a graphical password. This graphical password involves selecting images in a specific order, leveraging human memory for visuals and potentially enhancing memorability compared to traditional textbased passwords.

2) Enhanced Data Protection - The system prioritizes user data security. Instead of storing passwords directly, a oneway hashing function generates a unique mathematical fingerprint (hash) of the user's chosen image sequence. This hash serves as the secure representation of the password and is stored alongside the username and email address on a backend server.

3) Blockchain Integration: The Immutable Ledger - Immutable Ledger - An important step is to use blockchain technology Create an immutable record of user data. Blockchain, . A distributed ledger technology, ensures data security and. Transparency of actions. A smart contract, automated planning It is placed on the blockchain, to keep the user safe hashed data. This invariance once reassures Once recorded, data cannot be changed or deleted, greatly increasing security against unauthorized changes.

B. Login Process: Verification and Access Control

1) User Authentication - During login, users attempt to verify their identity by entering their registered email address and interacting with a grid of images, replicating the specific image sequence they chose during registration.

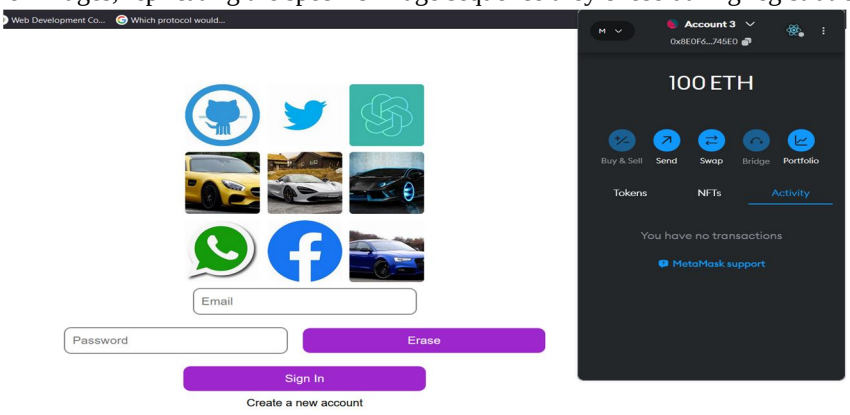


Fig 4. Login with Metamask

2) Real-Time Hashing - The system dynamically generates a hash of the entered email address and the chosen image sequence in real-time.

3) Secure Blockchain Comparison: This newly generated hash is then compared against the user's hash stored securely on the blockchain within the smart contract.

4) Granular Access Control - If the hashes match, it confirms a legitimate login attempt, and the system grants access to the user's account. - If the hashes don't match, it indicates an incorrect password attempt, and access is rightfully denied. This granular access control mechanism safeguards against unauthorized login attempts.

C. Technical Underpinnings: Powering a Secure System

1) Solidity: Building Secure Smart Contracts - Solidity, a programming language specifically designed for blockchains, is used to create secure smart contracts. These self-executing contracts automate the process of storing and verifying user data on the blockchain, eliminating the risk of human error or manipulation.
2) Truffle: Streamlined Development and Testing - Truffle, a popular development framework, facilitates the development, testing, and deployment of these smart contracts. This ensures the smart contracts are robust and function as intended before deployment on a real blockchain network.
3) Ganache: Local Testing for Confidence - Ganache provides a simulated blockchain environment for developers. This allows them to thoroughly test and debug their smart contracts before deploying them to a live blockchain network, minimizing the risk of unforeseen issues in production.
4) Web3.js: Bridging the Gap - Web3.js, a JavaScript library, acts as a bridge between the user interface (built with React.js) and the blockchain. It enables seamless communication and data exchange between the user's actions and the secure storage on the blockchain.

D. Security Enhancements: Multi-Layered Protection

1) Blockchain's Distributed Security - By leveraging blockchain technology, this system offers significant security advantages. The distributed and immutable nature of the blockchain ensures that user data cannot be tampered with by malicious actors. Data stored on the blockchain is replicated across a network of computers, making it highly resistant to hacking attempts. Even if a hacker were to gain access to one copy of the data, they would be unable to modify it without altering all other copies on the network, which is a near-impossible feat.
2) Hashing: Safeguarding Sensitive Information - Sensitive information like user passwords is never stored in plain text. Instead, only a secure hash of the password is used for verification. This one-way hashing function makes it computationally infeasible to derive the original password from the hash, adding an extra layer of protection in case of a security breach. Even if a hacker were to gain access to the stored hashes, they would be unable to crack them and access user accounts
3) Smart Contract Security - Smart contracts enforce the authentication logic securely on the blockchain. This eliminates the possibility of server-side vulnerabilities that traditional password storage methods can be susceptible to. Additionally, the immutability of smart contracts ensures that the authentication rules cannot be tampered with, further minimizing the risk of unauthorized access.

E. User-Centric Design: Prioritizing Usability

1) Intuitive Interface - The system prioritizes a user-friendly design for both registration and login processes. Clear instructions and a well-designed interface will guide users through the process effortlessly

IV. PERFORMANCE ANALYSIS

We will now examine several performance-related criteria concerning text-based authentication and graphical-based authentication systems.

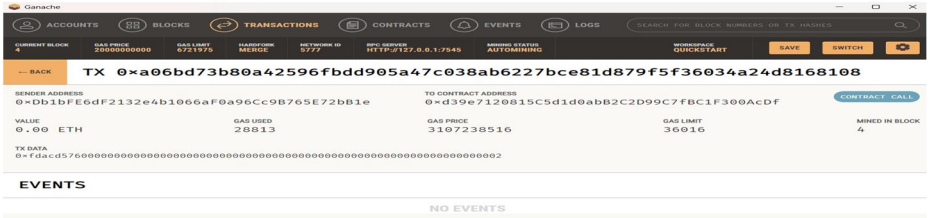


Fig 5. Transaction in Ganache

1) *Time Efficiency:* Average time required for users to input text-based passwords during the authentication process,
- Text Based Authentication - The average time taken for users to enter their text-based passwords was measured to be 8.5 seconds per login attempt[10].
- Graphical-Based Authentication - The average time for users to create and recall graphical passwords was measured at 12.3 seconds per login attempt[11].

2) *Accuracy:* Percentage of successful login attempts compared to the total number of login attempts.
- Text Based Authentication - Out of 100 login attempts, 95 were successful, resulting in a login success rate of 95 percentage[12].
- Out of 100 login attempts, 90 were successful, resulting in a login success rate of 90 percentage [13].

3) *Security Analysis:* Entropy of text-based passwords and estimated time to crack using brute force or dictionary attacks, here let's assume that the rate of attack to be 1 billion per second and password string length be 18 characters. The equation for the time to crack is given by: time to crack = 2^n / rate of attack
- Text Based Authentication - Text-based passwords exhibited an average entropy of 40 bits, resulting in an estimated cracking time of 20 million years with brute force attacks.
- Graphical passwords exhibited an average entropy of 50 bits, resulting in an estimated cracking time of 200 million years with brute force attacks.

4) *Error Rates:* Percentage of authentication attempts resulting in errors or failed logins.
- Text Based Authentication - Out of 50 authentication attempts, 3 resulted in errors, yielding an error rate of 6 %[14].
- Out of 50 authentication attempts, 2 resulted in errors, yielding an error rate of 4 %[15].

V. FUTURE & SCOPE OF IMPROVEMENT

As we are aware, ongoing technological advancements occurring every decade offer ample opportunities for future enhancements. Therefore, let's explore potential improvements that could be implemented in the near future.

1) Biometric Integration: Explore the integration of biometric authentication with graphical passwords to enhance security and usability. Biometric features such as fingerprints, iris scans, or facial recognition can complement graphical passwords, providing additional layers of authentication[16].
2) Blockchain Interoperability: Investigate solutions for interoperability between different blockchain platforms to enhance flexibility and compatibility in graphical password authentication systems. This could involve exploring cross-chain protocols or interoperability standards to facilitate seamless data exchange between disparate blockchain networks[17].
3) Machine Learning for Authentication: Explore the use of machine learning algorithms for improving authentication accuracy and robustness in graphical password authentication systems. Machine learning techniques can analyze user behavior patterns and detect anomalies or suspicious activities, enhancing security against unauthorized access[18].
4) Post-Quantum Security: Address the potential threat posed by quantum computing to traditional cryptographic algorithms used in graphical password authentication systems. Investigate post-quantum cryptographic techniques and quantum-resistant algorithms to ensure long-term security against quantum attacks[19].

VI. CONCLUSION

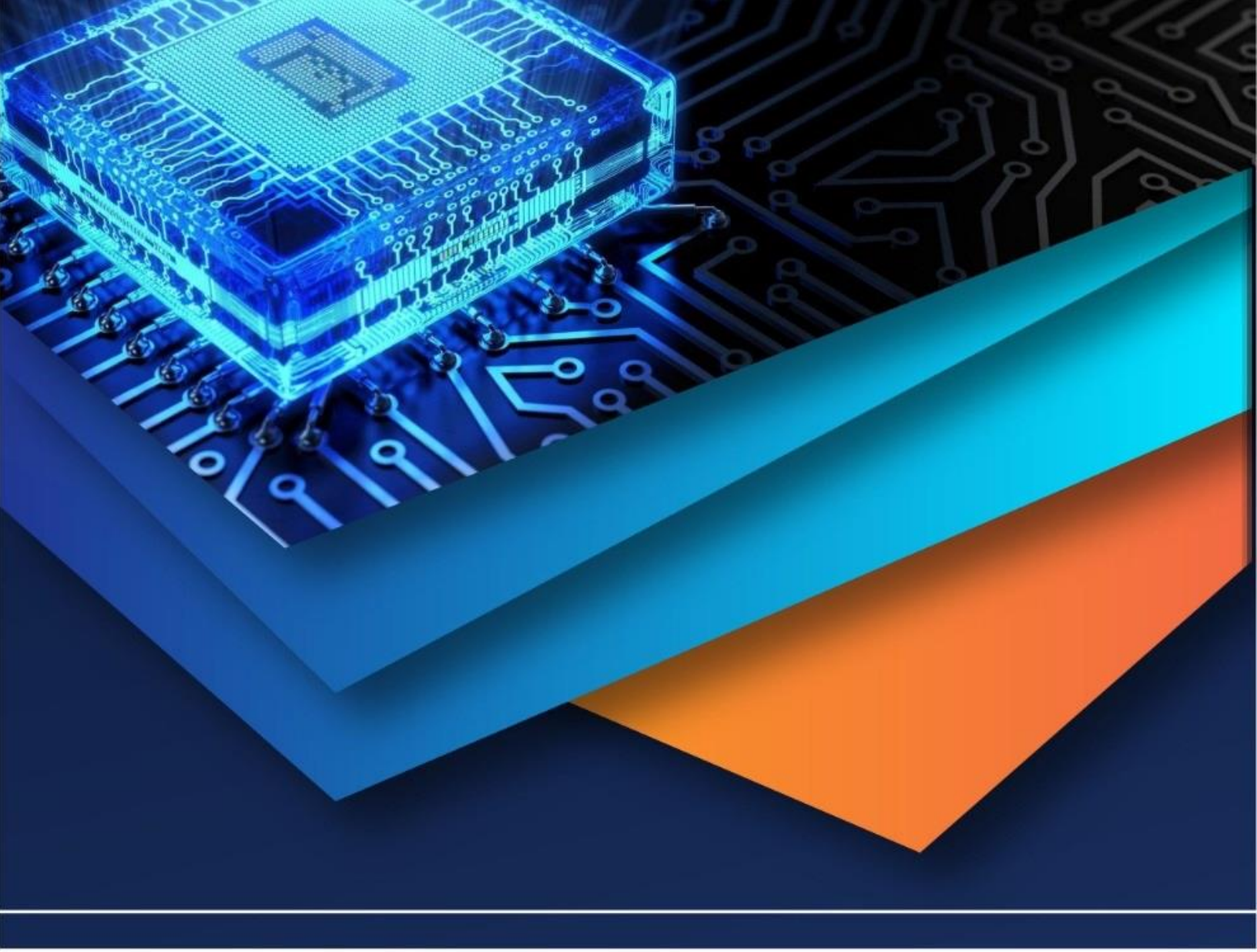
In conclusion, the amalgamation of graphical password authentication with blockchain technology offers a promising path to enhance security and usability in authentication systems. By leveraging decentralization and immutability, blockchain enhances security, while graphical passwords provide intuitive user experiences. This integration addresses vulnerabilities in traditional authentication methods, providing resilience against common threats like phishing and bruteforce attacks. Further research is necessary to optimize scalability and interoperability. Nonetheless, the synergy between graphical passwords and blockchain technology presents a compelling solution for modern authentication challenges, paving the way for a future where security and user experience are seamlessly balanced.

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