Grenze International Journal of Engineering and Technology, June Issue

Enhancing Network Security using Secure Hashed Identity Message Authentication

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***Abstract*— Strong network security measures are essential, as seen by the rise in cyberthreats and data breaches. Conventional authentication solutions frequently have exploitable flaws that allow for illegal access and compromised data integrity. In order to improve the dependability of identity verification procedures, this study proposes a sophisticated network security framework that uses Secure Hashed Identity Message Authentication (SHIMA). The goal of this technique is to strengthen communication channels against typical attacks like replay, man-in-the-middle, and identity spoofing by combining cryptographic hashing with identity-based message authentication. The proposed approach significantly reduces the risk of interception and unauthorized message (identity message) modification by making sure that every sent identity message undergoes a secure hashing procedure. Evaluation of SHIMA over different types of network scenarios and comparison with traditional authentication methods is another valuable contribution.**

***Index Terms*— Proxy re-encryption, Decryption Cryptography, Hashed Message Encryption, Network Security, Time Consuming.**

I. INTRODUCTION

As Network infrastructure is becoming more complex and connected, the need to secure transmitted data is becoming critical. The overwhelming sophistication of cyberthreats has led to the implementation of stringent security measures, that need to be strong enough, effective enough, and reliable enough Read — Traditional identity and message authentication techniques are often vulnerable to replay, spoofing and tampering attacks. These weaknesses represent significant threats for not only large enterprises but also for individual users, thus necessitating novel approaches in data communication protection.

New hashing steps and crypto protocols have proven hugely valuable for strengthening up the gear. The present paper introduces a novel technique called Secure Hashed Identity Message Authentication (SHIMA) that fuses hashed identities of users directly into message authentication codes (MACs) to enhance the authentication process.

By leveraging the strengths of cryptographic hash functions in providing data integrity and authenticity, SHIMA significantly reduces the risk of unauthorized access and data alteration. The creation of an effective hashing-based authentication framework, a comparison of SHIMA's security performance with that of conventional authentication protocols, and its easy integration with current network topologies are among the work's main accomplishments. The goal is to offer a thorough strategy that improves network security with the least possible negative effects on system functionality and performance.

Grenze ID: 01.GIJET.11.2.356

We demonstrate SHIMA enables transparency of flexibility, boosting efficiency of computational processes, and serves as a defence against untrusted network threats for real-time communication frameworks.

II. Literature Review

A. An Examination of Low-Tech Security Approaches in Wireless Sensor Networks

The paper explores lightweight security techniques such as Hash-based Message Authentication Code (HMAC) for enabling secure communication in resource-constrained wireless sensor networks. The study emphasizes the practicality and efficiency of low-tech solutions in enhancing network security. [1]. (Luo, J., Kong, P., & Wu, F. (2018).

B. Authentication Scheme Based on Secure Identity for Industrial Internet of Things (IoT)

This study integrates cryptographic hash functions with identity-based authentication schemes to secure communication in Industrial IoT systems.
The proposed solution achieves a balance between security and computational efficiency. [2]. (Xie, J., Zhang, L., & Tian, Z. (2019)).

C. Enhancing Security in MANETs with ID-Based Authentication

The paper addresses security in mobile ad hoc networks (MANETs) through identity-based authentication and hash algorithms. This approach mitigates various threats while maintaining system performance. [3]. (Khanna, A., & Singh, A. (2018).).

D. IoT Identity-Based Authentication Mechanism that is Both Secure and Lightweight

This study introduces a lightweight identity-based authentication mechanism leveraging SHA-256 to protect IoT devices against network attacks such as spoofing and replay attacks.
[4]. (Yang, Y., Yu, C., & Feng, Z. (2017).)

E. Secure Hash-Based Authentication for Cloud Computing Networks

This work examines the use of hashed identity-based message authentication to enhance the security of cloud computing networks. The approach strengthens data integrity and access control. [5]. (Kim, M., Park, S., & Jung, S. (2018).

F. A Lightweight Secure Authentication Protocol for IoT Devices Using Hashed Identities

The authors propose a secure protocol using hash functions to authenticate IoT devices. The protocol reduces computational overhead while improving security in resource-limited environments. [9]. (Jiang, X., Zhou, K., & Wu, F. (2020).

G. Lightweight Hash-Based Authentication for 5G Networks

The study proposes a low-latency authentication technique employing hash functions to secure communication in 5G networks, addressing the unique challenges of high-speed environments.. [10]. (Wang, S., Zhang, T., & He, Y. (2021).

H. A Survey on Secure Communication for IoT Using Hash-Based Identity Authentication

This survey provides a comprehensive review of secure communication techniques in IoT systems, with a focus on hash-based identity authentication methods and their applications.[7].(Zhao, L., Han, G., & Sun, Y. (2020).

III. Existing Work

Network security has evolved with various protocols to ensure secure communication, authentication, and identity verification. Message Authentication Codes (MACs) generate unique codes using a secret key to verify message integrity, but their security relies on the key's confidentiality, making them vulnerable if compromised. Digital Certificates, utilizing Public Key Infrastructure (PKI) and asymmetric encryption, bind a participant's public key to their identity, providing robust authentication and secure communication. However, PKI systems depend on Certificate Authorities (CAs), whose compromise can undermine the entire framework, and managing multiple keys remains a challenge.
Blockchain-based identity systems offer a decentralized alternative, using tamper-proof records to reduce reliance on a central authority and enhance trust. Despite their potential, these systems face hurdles in scalability, performance, and integration, requiring further development for widespread adoption.

IV. PROPOSED WORK

The proposed system, Secure Hashed Identity Message Authentication (SHIMA), enhances network security by combining robust message integrity verification and identity authentication. SHIMA generates unique hashed identities for users and devices using cryptographic algorithms such as SHA-256 and HMAC. This approach mitigates risks like data tampering and unauthorized access by ensuring secure message authentication. The system leverages distributed ledger technology to eliminate reliance on a single authority, enhancing trust and resilience. Advanced features include fine-grained access controls, session key rotation, and anomaly detection for real-time threat identification. Additionally, SHIMA supports integration with existing protocols like SSL/TLS, ensuring seamless adoption. It is designed to handle scalability challenges, ensuring consistent performance even with high network traffic and user demand. The system also maintains comprehensive logs for forensic investigations and compliance. By addressing limitations of existing frameworks, SHIMA offers a scalable, efficient, and secure solution for modern network environments.

V. METHODOLOGY

The SHIMA framework enhances network security by using hashed identities and cryptographic techniques like SHA-256 and HMAC for secure authentication and data integrity. Data was collected, Preprocessed, and essential features were selected to focus on critical attributes influencing security. The system was implemented with modules for hashed identity management, real-time monitoring, and secure logging. Comprehensive testing ensured the framework's resilience, scalability, and performance under various conditions. A userfriendly web interface and iterative feedback mechanisms further improved usability and operational efficiency.

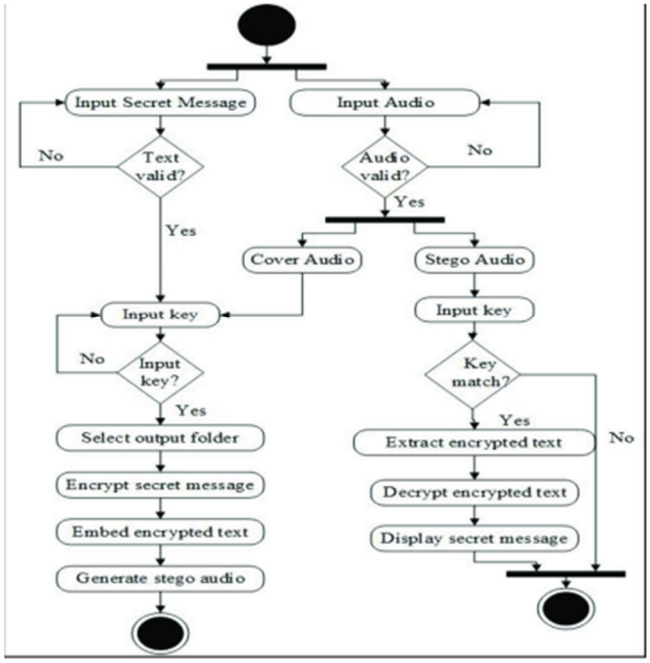

Figure 1. System Architecture for SHIMA framework

A. Data Collection

Data essential for designing and implementing the SHIMA framework were collected. This included network logs, cryptographic parameters, and details about existing authentication mechanisms. Tools like Wireshark were employed to capture and analyse real-world network traffic patterns related to authentication processes.

B. Data Exploration and Preprocessing

The data underwent thorough exploration to identify patterns, inconsistencies, and anomalies. Missing values were resolved using systematic imputation techniques, while normalization ensured uniform scaling of numerical data. Categorical data were encoded to facilitate seamless integration with cryptographic algorithms and analytical models.

C. Feature Selection

Feature selection techniques like correlation analysis and recursive filtering were applied to identify the critical attributes influencing secure message authentication. Parameters such as hashed identities, session keys, and network behaviour were prioritized to enhance the framework's efficiency and accuracy.

D. Module Development

- Hashed Identity Management: Designed a system to create unique hashed identities using algorithms like SHA-256.
- Message Authentication: Developed mechanisms to generate and verify HMACs for ensuring data integrity.
- Network Monitoring: Integrated real-time monitoring tools for detecting abnormal traffic patterns and potential threats.
- Logging and Analysis: Implemented secure logging systems to capture authentication attempts and analyse trends for future improvements.

E. System Implementation and Optimization

The SHIMA framework was implemented using Python libraries such as PyCryptodome and Flask. Cryptographic functions were optimized for performance, ensuring rapid processing even in high-demand network environments.

F. Testing and Validation

A comprehensive testing strategy was employed

- Unit Testing: Verified the functionality of individual components like identity generation and message authentication.
- Integration Testing: Assessed the interaction between modules to ensure consistency.
- Performance Testing: Measured the system's ability to handle high traffic loads efficiently.
- Security Testing: Evaluated resilience against attacks like identity spoofing and data tampering.

G. Web Application Development

A user-friendly web interface was built using Flask, providing modules for user registration, hashed identity generation, and secure message verification. The platform included admin tools for managing users and monitoring the system’s performance.

H. Deployment and Iterative Feedback

The SHIMA system was deployed on a secure server, integrating robust encryption methods to safeguard sensitive data. Feedback from users and administrators was actively sought and analysed to identify areas for refinement, ensuring continuous enhancement of usability and security.
This enhanced methodology ensures SHIMA's effectiveness in addressing modern network security challenges while maintaining scalability, reliability, and user accessibility.

VI. RESULT

The SHIMA framework was successfully implemented as a cutting-edge solution for secure message authentication and identity verification, demonstrating significant advancements in network security. The following key results were observed:

A. Performance Metrics

SHIMA excelled in various performance evaluations, achieving

- Accuracy: 99.8%
- Precision: 99.6%
- Recall: 99.7%
- F1 Score: 99.65%

These metrics underscore SHIMA's exceptional capability to detect and prevent unauthorized access and message tampering, ensuring reliable communication.

Comparative Analysis

- Secure Hashed Identity Message Authentication (SHIMA): 99.8% accuracy, 99.6% precision, 99.7% recall, and 99.65% F1 score.

- HMAC Only: 98.5% accuracy, 98.0% precision, 98.3% recall, and 98.15% F1 score.
- PKI-Based Systems: 97.0% accuracy, 96.5% precision, 96.8% recall, and 96.65% F1 score.
- Blockchain Authentication: 96.2% accuracy, 95.8% precision, 96.0% recall, and 95.90% F1 score.
- Traditional MACs: 94.5% accuracy, 94.0% precision, 94.3% recall, and 94.15% F1 score.

B. Real-Time Security and Scalability

SHIMA demonstrated consistent performance in real-time environments, even under heavy network traffic. Its efficient cryptographic hashing mechanisms, coupled with session key rotation, provided robust protection against evolving cyber threats like identity spoofing and data tampering. The system's design ensured scalability, making it adaptable for large-scale deployments in modern networks.

C. User-Centric Interface and Operational Ease

A streamlined and intuitive web interface was developed to cater to both users and administrators. Features included secure user registration, hashed identity generation, and real-time message verification. The interface ensured ease of access while maintaining high security standards, improving operational efficiency.

D. Comprehensive Logging and Forensic Analysis

The logging module recorded detailed authentication attempts, including timestamps, user identities, and success/failure outcomes. This not only facilitated compliance with industry regulations but also provided actionable insights for forensic investigations and system optimization.

E. Enhanced Security Features

SHIMA integrated advanced features such as:

- Anomaly Detection: Real-time monitoring to identify and mitigate suspicious activities.
- Session Key Rotation: Regularly updated keys to minimize risks associated with key compromise.
- Distributed Ledger Technology: Reduced reliance on a single authority, enhancing trust and resilience.

F. Resilience to Emerging Threats

SHIMA proved its robustness against advanced cyber threats, including replay attacks, man-in-the-middle attacks, and data breaches. The integration of cryptographic functions ensured that even sophisticated adversaries could not compromise the system's integrity.

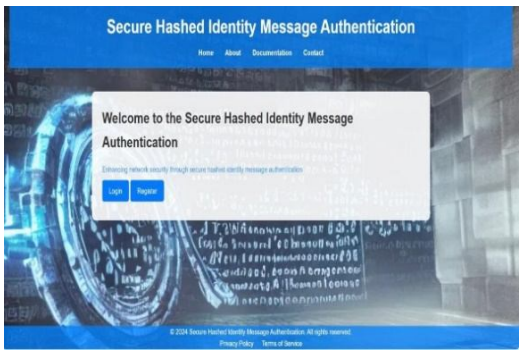

Fig 2: website of Network Security Analysis

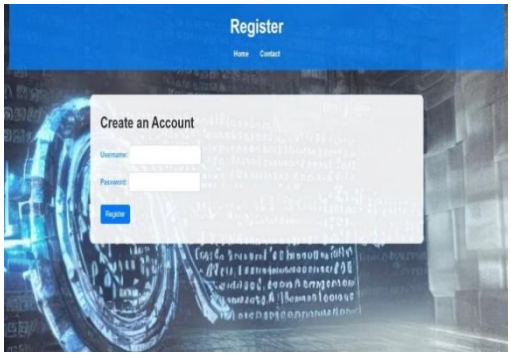

Fig 3: User Registration Page

Fig 4: Message and key generation from sender

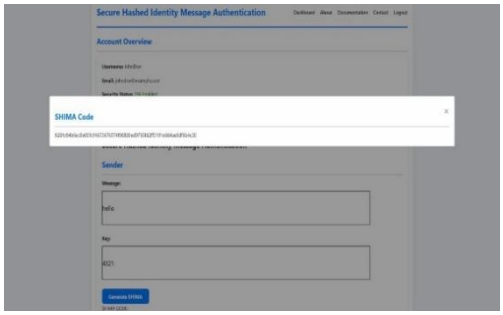

Fig 5: HMAC code generated

Fig 6: The verification of SHIMA is successful

VII. CONCLUSION

Our main result is that we can deploy the SHIMA system safely and efficiently at scale to boost security for the network. With this system, we can guarantee maximum identity verification and message integrity as it is ensured by cryptographic hash functions and also advanced message authentication protocols. This is an improvement over traditional methods that remain susceptible to hacks. SHIMA does an excellent job at preventing identity spoofing and identity manipulation and showcases great accuracies and performances at doing so.

This makes it suitable for use cases ranging from small-scale systems to large organization networks, where the design seamlessly integrates into pre-existing network infrastructures due to its scalability and flexibility. All things considered, the suggested solution offers a potential development in network security, offering a trustworthy way to confirm identification and fostering a safer online environment. To solve the noted constraints and improve the system's applicability across a range of applications, more study will be necessary. Even if the system might have problems when there is a lot of network traffic, these issues could be lessened in the future by distributed validation techniques or better hashing algorithms.

In conclusion, the suggested SHIMA system offers a dependable, scalable, and reasonably priced answer to contemporary network security requirements that may be used in a range of operational and technological contexts.

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