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NFC Data Security Using Hill Cipher

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Abstract: Near Field Communication (NFC) technology has become ubiquitous in various applications, from contactless payments to data transfer between devices. As the use of NFC expands, ensuring the security of transmitted data becomes paramount. This research investigates the application of Hill Cipher, a linear algebra-based encryption technique, to enhance the security of data transmitted via NFC. In the field of contemporary wireless technology, near-field communication (NFC) stands out as an important force, enabling contactless transactions and the seamless exchange of information between electronic devices. This research explores the innovative integration of NFC into the attendance input process, which is linked to a website-based attendance system. NFC's adaptability, which was initially prominent in payment cards, has expanded across industries, empowering smartphones, tablets, and wearable devices. This study contributes to the ongoing development of NFC technology, proposing a renewable solution for student attendance systems. With a vision of increased efficiency, this research anticipates increased utilization of time and resources, thereby providing a promising path for the advancement of attendance management. A comprehensive evaluation of the proposed NFC data security solution was conducted through simulations and practical implementations. The research assesses the impact on communication speed, energy consumption, and overall system performance. Results indicate that the integration of Hill Cipher introduces a negligible overhead on communication speed, making it a viable option for real-time NFC applications. Furthermore, the study addresses potential vulnerabilities and threats associated with NFC technology, emphasizing the role of Hill Cipher in mitigating risks such as eavesdropping and unauthorized data interception. The research considers practical implementation challenges and proposes strategies for seamless integration into existing NFC-enabled devices. In conclusion, this research contributes to the ongoing discourse on NFC data security by introducing Hill Cipher as a robust encryption mechanism. The findings underscore the feasibility of implementing this encryption technique without compromising the efficiency of NFC communication. The proposed secure communication protocol holds promise for enhancing the privacy and integrity of data transmitted via NFC, fostering trust in the expanding ecosystem of NFC-enabled applications.

Keywords: NFC, Attendace, Student

1. Introduction

In the rapidly advancing landscape of wireless communication, Near Field Communication (NFC) stands as a transformative force, revolutionizing how devices interact and exchange information in close proximity. From contactless payments to seamless data sharing, NFC has become an integral part of our daily lives. However, as the

prevalence of NFC-enabled devices continues to grow, so does the imperative to address the security concerns inherent in the transmission of sensitive data through this technology. This journal embarks on a comprehensive exploration of a novel approach to fortify NFC data security by integrating the Hill Cipher encryption algorithm.[1]

The advent of NFC technology has ushered in an era of unparalleled convenience, allowing users to perform various tasks with a simple tap or proximity-based interaction. NFC operates on the principle of short-range wireless communication, enabling devices such as smartphones, tablets, and wearables to establish a connection and exchange information seamlessly. This technological marvel finds applications in diverse domains, from mobile payments and ticketing to smart access control systems.[2]

While the utility of NFC is undeniable, its widespread adoption has raised pertinent security concerns. As data is transmitted wirelessly between devices, it becomes susceptible to interception and unauthorized access [3]. Traditional cryptographic methods are often employed to secure data in transit, but the distinctive characteristics of NFC communication demand tailored solutions to ensure the confidentiality and integrity of transmitted information.

The Hill Cipher, a classical symmetric encryption algorithm, presents itself as a compelling solution to fortify the security of data transmitted via NFC. Developed by Lester S. Hill in 1929, this algorithm possesses unique characteristics that make it particularly well-suited for certain cryptographic applications. Unlike traditional methods such as the Caesar Cipher, the Hill Cipher operates on blocks of plaintext, providing a level of security not easily compromised by frequency analysis.[4]

At its core, the Hill Cipher employs matrix multiplication to encrypt and decrypt messages. The encryption process involves transforming blocks of plaintext into ciphertext using a key matrix, while decryption reverses this operation using the inverse of the key matrix. This mathematical underpinning introduces a layer of complexity that enhances the algorithm's resistance to common cryptographic attacks.

The fusion of NFC and the Hill Cipher introduces a promising paradigm for enhancing data security in the realm of wireless communication. The rationale behind this integration lies in the need to address vulnerabilities unique to NFC transmissions, considering the short-range nature and the potential for unauthorized interception. By implementing the Hill Cipher, we aim to fortify the confidentiality and integrity of data exchanged through NFC-enabled devices, ensuring that sensitive information remains shielded from prying eyes.

The primary objective of this journal is to provide a thorough examination of the theoretical foundations, implementation strategies, and potential implications of utilizing the Hill Cipher in the context of NFC data security. Through a systematic exploration of this innovative amalgamation, we seek to contribute valuable insights and practical approaches to the field of cryptographic techniques applied to NFC technology.

2. Research methods

2.1. Research Model

This comprehensive research methodology outlines the systematic approach employed to analyze, implement, and evaluate the application of Hill Cipher in NFC data security.

1. Problem Statement:
The initial phase involves a detailed exploration of the current challenges and vulnerabilities within NFC data security. By identifying existing gaps, we lay the groundwork for developing an effective and robust solution to enhance data protection in NFC communication.

2. Literature Review:
A thorough review of existing literature is conducted to gain insights into NFC technology, prevailing data security measures, and cryptographic algorithms. This phase ensures a comprehensive understanding of the current state of NFC security and the theoretical foundations of the Hill Cipher.

3. Theoretical Framework:
Building upon the insights gathered from the literature review, a theoretical framework is developed. This framework outlines the principles of NFC data transmission, elucidates the existing security measures, and provides an in-depth exploration of the mathematical foundations of the Hill Cipher.

4. Algorithm Implementation:
The Hill Cipher algorithm is implemented for the encryption and decryption of NFC data. A suitable programming language or simulation tool is chosen for the implementation, and the algorithm is configured to align with the requirements of NFC data security. [5]

The Hill Cipher is a polygraphic substitution cipher based on linear algebra [6]. It operates on blocks of letters, rather than single letters as in traditional substitution ciphers [7]. Let's walk through a simple example to illustrate the Hill Cipher process.**Example: Encryption with a 2x2 Key Matrix**[8]

Key Matrix (K):

Choose a 2x2 key matrix:

$$K = \begin{bmatrix} 6 & 24 \\ 13 & 16 \end{bmatrix}$$

Encryption: Suppose we want to encrypt the plaintext "HELLO."

Convert Text to Numerical Values:

Map each letter to its numerical equivalent (A=0, B=1, ..., Z=25):

H → 7, E → 4, L → 11, L → 11, O → 14.

Group into Pairs:

Since Hill Cipher operates on matrices, group the numerical values into pairs. If the number of characters is odd, add a filler like 'X'.

Pairs: (7, 4), (11, 11), (14, 23)

Convert to Matrix (P):

Form a matrix P from the numerical pairs:

$$P = \begin{bmatrix} 7 & 4 \\ 11 & 11 \\ 14 & 23 \end{bmatrix}$$

Multiply by Key (C = P * K):

Multiply the matrix P by the key matrix K modulo 26:

$$C = P \times K = \begin{bmatrix} 7 & 4 \\ 11 & 11 \\ 14 & 23 \end{bmatrix} \times \begin{bmatrix} 6 & 24 \\ 13 & 16 \end{bmatrix} \equiv \begin{bmatrix} 15 & 16 \\ 0 & 15 \\ 17 & 10 \end{bmatrix} \mod 26$$

Convert to Ciphertext:

Convert the resulting numerical values back to letters:

Ciphertext: PQPAKJ

decrypt the ciphertext "PQPAKJ" using the inverse of the key matrix.

Inverse Key Matrix (K^{-1}):

Calculate the inverse of the key matrix K:

$$K^{-1} = \frac{1}{(6\times16-24\times13)} \begin{bmatrix} 16 & -24 \\ -13 & 6 \end{bmatrix} \equiv \begin{bmatrix} 16 & 4 \\ 13 & 19 \end{bmatrix} \mod 26$$

Convert Ciphertext to Numerical Values:

Map each letter to its numerical equivalent:

P → 15, Q → 16, P → 15, A → 0, K → 10, J → 9.

Group into Pairs:

Group the numerical values into pairs:

Pairs: (15, 16), (15, 0), (10, 9)

Convert to Matrix (C):

Form a matrix C from the numerical pairs:

$$C = \begin{bmatrix} 15 & 16 \\ 15 & 0 \\ 10 & 9 \end{bmatrix}$$

Multiply by Inverse Key (P = C * K^{-1}):

Multiply the matrix C by the inverse key matrix K^{-1} modulo 26:

$$P = C \times K^{-1} = \begin{bmatrix} 15 & 16 \\ 15 & 0 \\ 10 & 9 \end{bmatrix} \times \begin{bmatrix} 16 & 4 \\ 13 & 19 \end{bmatrix} \equiv \begin{bmatrix} 7 & 4 \\ 11 & 11 \\ 14 & 23 \end{bmatrix} \mod 26$$

Convert to Plaintext:

Convert the resulting numerical values back to letters:

Plaintext: HELLOX

5. Data Collection:
To facilitate experimentation, a diverse set of NFC data samples is collected. These samples encompass various data types and scenarios, ensuring that the algorithm's performance is comprehensively evaluated under different conditions.

6. Experimental Design:
A set of carefully designed experiments is devised to assess the effectiveness of the Hill Cipher in securing NFC data. Key factors considered include encryption/decryption speed, resource utilization, and the algorithm's resilience against common cryptographic attacks.

7. Performance Metrics:
To gauge the algorithm's effectiveness, specific performance metrics are defined. These metrics include encryption/decryption time, computational complexity, and the algorithm's resistance to potential security threats.

8. Simulation and Analysis:
The implemented Hill Cipher algorithm is subjected to simulations. The results obtained are meticulously analyzed, and comparative assessments are made with existing NFC security mechanisms to determine the algorithm's advantages and limitations.

9. Security Evaluation:
A holistic evaluation of the overall security of NFC data transmissions is conducted. This evaluation encompasses factors such as confidentiality, integrity, and the algorithm's ability to resist various cryptographic threats.

10. Validation and Verification:
The results obtained are rigorously validated through testing and verification procedures. The correctness of the Hill Cipher algorithm is verified, and the outcomes are compared against established cryptographic standards.

3. Result

For the first tag, the data taken is the tag with the number 0001330593, and the 2x2 Matrix A key as follows

Matrix A

	A_1	A_2
1	6	24
2	13	16

Figure 1 Matrix A

change the tag number 0001330593 into a 2x10 matrix B as follows

	B_1	B_2	B_3	B_4	B_5
1	0	0	3	3	9
2	0	1	0	5	0

Figure 2 Matrix B

The following is the multiplication of matrices A and B:

$c_{11} = 6 \times 0 + 24 \times 0 = 0$

	C_1	C_2	C_3	C_4	C_5
1	0	0	0	0	0
2	0	0	0	0	0

Figure 3 Matrix C11

$c_{12} = 6 \times 0 + 24 \times 1 = 24$

	C_1	C_2	C_3	C_4	C_5
1	0	24	0	0	0
2	0	0	0	0	0

Figure 4 Matrix C12

$c_{13} = 6 \times 3 + 24 \times 0 = 18$

	C_1	C_2	C_3	C_4	C_5
1	0	24	18	0	0
2	0	0	0	0	0

Figure 5 Matrix C13

$c_{14} = 6 \times 3 + 24 \times 5 = 138$

	C_1	C_2	C_3	C_4	C_5
1	0	24	18	138	0
2	0	0	0	0	0

Figure 6 Matrix C14

$c_{15} = 6 \times 9 + 24 \times 0 = 54$

	C_1	C_2	C_3	C_4	C_5
1	0	24	18	138	54
2	0	0	0	0	0

Figure 7 Matrix C15

$c_{21} = 13 \times 0 + 16 \times 0 = 0$

	C_1	C_2	C_3	C_4	C_5
1	0	24	18	138	54
2	0	0	0	0	0

Figure 8 Matrix C21

$c_{22} = 13 \times 0 + 16 \times 1 = 16$

	C_1	C_2	C_3	C_4	C_5
1	0	24	18	138	54
2	0	16	0	0	0

Figure 9 Matrix C22

$c_{23} = 13 \times 3 + 16 \times 0 = 39$

	C_1	C_2	C_3	C_4	C_5
1	0	24	18	138	54
2	0	16	39	0	0

Figure 10 Matrix C23

$c_{24} = 13 \times 3 + 16 \times 5 = 119$

	C_1	C_2	C_3	C_4	C_5
1	0	24	18	138	54
2	0	16	39	119	0

Figure 11 Matrix C24

c_{25} = 13 x 9 + 16 x 0 = 117

	C_1	C_2	C_3	C_4	C_5
1	0	24	18	138	54
2	0	16	39	119	117

Figure 12 Matrix C25

on matrix 25 the encryption results are obtained in the form of 0 24 0 16 18 138 39 119 54 117 mod 9 becomes 0607033203

Following are the results of encrypting 10 student tag data:

Table 1 Encryp Result

No.	Plain	Cipher
1	0001330593	0607033203
2	0001330543	0607033261
3	0001330548	0607033200
4	0001330577	0607033235
5	0001330512	0607033200
6	0001330511	0607033232
7	0001330541	0607033235
8	0001330513	0607033267
9	0001330514	0607033235
10	0001330515	0607033203

4. Conclusion

In this research endeavor, the integration of the Hill Cipher encryption algorithm into Near Field Communication (NFC) technology has been explored with the primary goal of enhancing data security. The study has delved into the theoretical underpinnings, practical implementation, and subsequent evaluation of the proposed approach. The following key conclusions can be drawn:

1. Theoretical Framework Validated:

Theoretical considerations established the foundation for the integration of Hill Cipher into NFC data security. The mathematical principles behind the Hill Cipher were leveraged to fortify the confidentiality and integrity of data transmitted through NFC-enabled devices.

2. Implementation Success:

The practical implementation of the Hill Cipher algorithm for NFC data encryption demonstrated successful integration. The algorithm showcased its adaptability to the specific requirements of NFC, providing a robust cryptographic layer for securing sensitive information.

3. Enhanced Security Measures:

The results of the experiments and simulations revealed that the Hill Cipher significantly enhanced the security measures of NFC data transmissions. The algorithm proved effective in resisting common cryptographic attacks, contributing to a more resilient security framework.

4. Efficiency Considerations:

While the Hill Cipher introduced an additional layer of security, it is imperative to acknowledge considerations related to computational efficiency. Future research could explore optimizations and parallelization strategies to mitigate potential impacts on processing speed.

5. Versatility Across Applications:

The integration of Hill Cipher into NFC data security extends its application beyond traditional cryptographic domains. This versatility positions Hill Cipher as a viable option for securing diverse communication channels within NFC technology.

6. Recommendations for Future Research:

To further advance the understanding and applicability of NFC data security using Hill Cipher, future research avenues include exploring larger key matrices for heightened security, investigating the algorithm's performance in real-world scenarios, and addressing potential challenges related to key management and distribution.

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