Design of Hybrid Cryptography System based on AES and RSA Algorithm

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Abstract— The Rijndael algorithm mainly consists of a symmetric block cipher that can process data blocks of 128, 192 or 256 bits by using key lengths of 128, 196 and 256 bits. This work using Rijndael cryptography symmetric algorithm for data encryption/decryption and RSA cryptography asymmetric algorithm for Rijndael key's encryption/decryption. The encryption and decryption of any data has a secure key, which is used for data encryption. For this purpose asymmetric key is used. This work securing the data key using RSA algorithm. Here RSA key size is 128-bytes. This work also generating two pairs of keys; public and private key. Using Public key it encrypts the data key and other one is public and private key pair ,which will send to other person, so that opposite person can decrypt the encrypted key using his public and private key..

Index Terms— Advanced Encryption Standard (AES), Symmetric key asymmetric key, RSA Encryption, Cryptography

I. Introduction

The interpolation attack is a technique for attacking block ciphers built from simple algebraic functions. A block cipher algorithm may not include any algebraic property that can be efficiently distinguishable, since an interpolation attack can be applied to such a block cipher which leads to the leakage of information about the secret key. This mathematical property has effective implications using a block cipher with a fixed secret key. If the cipher text is described as a polynomial with unknown coefficients-of the plaintext, and if the degree of this polynomial is sufficiently low, then a limited number of plaintext-cipher text pairs are capable to completely determine the encryption function. Constructing this polynomial will not immediately yield the key. Actually this is a polynomial that emulates the encryption function. It produces valid cipher text from given plaintexts. It can be applied by constructing an implicit polynomial expression involving parts of the plaintext and the cipher text. Now, we can check the polynomial against another value that was not used in the construction to test it. If the polynomial produces the correct result, then we have guessed the key bits. This allows the cryptanalyst to encrypt and decrypt data for the unknown key without doing any keyrecovery. This work describes the main parts of AES (RIJNDAEL) which consists of the individual transformations and AES S-box. We will introduce the interpolation attack with considering of the points of weakness and strength in AES S-box. Finally, we will discuss the manner of doing interpolation attack using the different representations of AES S-box.

Security of the system rests in part on the difficulty of factoring the published divisor, in cryptographic algorithm that can be used to protect electronic data. The AES algorithm is asymmetric block cipher that can encrypt (encipher) and decrypt (decipher) information. Encryption converts data to an unintelligible form called cipher text; decrypting the cipher text converts the data back into its original form, called plaintext. The AES algorithm is capable of using cryptographic keys of 128, 192, and 256 bits to encrypt and decrypt data in blocks of 128 bits. Data security has evolved rapidly since 1975. It have seen exciting developments in cryptography: public-key encryption, digital signatures, the Data Encryption Standard (DES), key safeguarding schemes, and key distribution protocols. It have developed techniques for verifying that programs do not leak confidential data, or transmit classified data to users with lower security clearances. It has found new controls for protecting data in statistical databases--and new methods of attacking these databases. It have come to a better understanding of the theoretical and practical limitations to security. An encryption method is presented with the novel property that publicly revealing an encryption key does not thereby reveal the corresponding decryption key. This has two important consequences: Couriers or other secure means are not needed to transmit keys, since a message can be enciphered using an encryption key publicly revealed by the indented recipient. Only he can decipher the message, since only he knows the corresponding decryption key. A message can be "signed" using a privately held decryption key. Anyone can verify this signature using the corresponding publicly revealed encryption key. Signatures cannot be forged, and a signer cannot later deny the validity of his signature. This has obvious applications in "electronic mail" and "electronic funds transfer" systems. A message is encrypted by representing it as a number M, raising M to a publicly specified power, and then taking the remainder when the result is divided by the publicly specified product, n, of two large secret primer numbers p and q. similar; only a different, secret, power d is used, where $e * d \equiv 1 (\mathrm{mod}\ (p - 1) * (q - 1))$.

II. Proposed Research Work

The aim of this research is to develop an advanced hybrid cryptography system that combines the AES (Advanced Encryption Standard) and RSA (Rivest-Shamir-Adleman) algorithms to enhance data security and confidentiality. The proposed system will leverage the strengths of both symmetric

and asymmetric encryption techniques to provide robust protection for sensitive information during transmission.

The research will focus on the following key components:

1. AES Algorithm Implementation:

- The AES algorithm, known for its efficiency and security, will be implemented as the symmetric encryption method in the hybrid system.

- The implementation will involve designing and developing the necessary modules and functions for key generation, encryption, and decryption using AES.

- Different key lengths and block sizes will be considered to assess the impact on performance and security.

2. RSA Algorithm Integration:

- The RSA algorithm, a widely used asymmetric encryption method, will be integrated into the hybrid system for secure key exchange.

- The research will explore techniques to generate and manage RSA key pairs efficiently.

- The integration will involve encrypting the AES-generated session key using the recipient's public key and decrypting it using the corresponding private key.

3. Hybrid Cryptography System Design:

- The AES and RSA algorithms will be combined in a seamless manner to create a hybrid cryptography system.

- The system will incorporate a user-friendly interface for ease of use and will provide options for selecting encryption parameters, such as key lengths and encryption modes.

- The design will ensure compatibility with different data formats and the ability to handle large files effectively.

4. Performance Evaluation and Analysis:

The proposed hybrid cryptography system will be extensively evaluated and analyzed for its performance, security, and efficiency.

Benchmark datasets and real-world scenarios will be utilized to assess the system's encryption/decryption speed, memory utilization, and resistance to various attacks.

- Comparative analysis will be conducted to measure the performance of the hybrid system against traditional symmetric or asymmetric encryption approaches.

5. Experimental Validation:

- To validate the effectiveness of the proposed hybrid cryptography system, practical experiments will be conducted on a testbed.

- The experiments will involve encrypting and decrypting data using different encryption modes, key lengths, and file sizes.

- The results will be compared with existing encryption techniques to demonstrate the superiority of the hybrid system in terms of security and performance.

The proposed research work aims to contribute to the field of data security by developing an advanced hybrid cryptography system. The integration of AES and RSA algorithms will provide a robust and efficient solution for protecting sensitive information during transmission. The findings and insights gained from this research will serve as a foundation for further advancements in hybrid cryptography and ensure secure communication in the digital era.

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III. THEORIES

Certainly! Here's an example of a Theories section for a research paper on hybrid cryptography, including mathematical aspects:

Theories

1. Symmetric Encryption - Advanced Encryption Standard (AES)

Symmetric encryption algorithms, such as the Advanced Encryption Standard (AES), are based on the concept of using a single shared secret key for both encryption and decryption processes. AES operates on fixed-size data blocks and employs a series of mathematical transformations to ensure data confidentiality. The key mathematical components of AES include:

- SubBytes Transformation: This transformation involves replacing each byte of the input data with a corresponding byte from a substitution table, known as the S-Box. The S-Box is generated using mathematical operations, such as inversion and affine transformations, to provide non-linear substitution.

ShiftRows Transformation: In this step, the bytes in each row of the data block are cyclically shifted, creating diffusion and increasing the complexity of the encryption process.

MixColumns Transformation: This transformation applies matrix operations to the columns of the data block, providing diffusion and enhancing the resistance against linear attacks.

AddRoundKey Transformation: The AddRoundKey step involves bitwise XORing of the data block with a round key derived from the original secret key. This step introduces confusion and ensures that each round contributes to the overall encryption strength.

The mathematical properties and operations employed in AES guarantee its security and make it resistant to various cryptographic attacks.

2. Asymmetric Encryption - Rivest-Shamir-Adleman (RSA)

Asymmetric encryption algorithms, such as the Rivest-Shamir-Adleman (RSA) algorithm, utilize a pair of mathematically related keys: a public key and a private key. RSA relies on the difficulty of factoring large prime numbers to provide data security. The key mathematical concepts in RSA include:

- Key Generation: The generation of the RSA key pair involves selecting two distinct prime numbers and performing mathematical operations, such as modular arithmetic and exponentiation, to determine the public and private keys. The security of RSA is based on the computational complexity of factoring large numbers into their prime factors.

- Encryption and Decryption: RSA encryption involves raising the plaintext message to the power of the recipient's public key modulo the product of two large prime numbers. Decryption, on the other hand, is achieved by raising the ciphertext to the power of the recipient's private key modulo the same product.

- Digital Signatures: RSA can also be used to generate digital signatures, which provide data integrity and authentication. The signing process involves applying a mathematical function to the message using the sender's private key, while the verification process utilizes the sender's public key to verify the signature's authenticity.

The mathematical properties of RSA, such as the difficulty of factoring large numbers and the use of modular arithmetic, ensure the security of the encryption and digital signature processes.

3. Hybrid Cryptography - Combining AES and RSA

The proposed hybrid cryptography system combines the strengths of AES and RSA to enhance data security and confidentiality. The AES algorithm is employed for symmetric encryption/decryption of the actual data, while RSA is used for securing the data key during transmission. The key mathematical aspects of the hybrid cryptography system include:

- Key Exchange: To securely transmit the AES-generated data key to the intended recipient, RSA is used for key exchange. The sender encrypts the data key using the recipient's public key, ensuring that only the recipient with the corresponding private key can decrypt and retrieve the key.

- Symmetric Encryption: AES is then utilized to encrypt the actual data using the securely exchanged data key. The mathematical transformations involved in AES, as discussed earlier, provide robust encryption and confidentiality.

- Decryption: At the recipient's

end, RSA decryption is applied to retrieve the AES data key using the recipient's private key. This key is then used for AES decryption to obtain the original plaintext.

The combination of AES and RSA leverages the advantages of both symmetric and asymmetric encryption, ensuring a secure and efficient hybrid cryptography system.

The mathematical theories underlying symmetric encryption (AES), asymmetric encryption (RSA), and the hybrid cryptography system provide a solid foundation for understanding the principles and operations involved in secure data transmission. These theories enable the development of robust cryptographic algorithms and protocols that guarantee data confidentiality, integrity, and authentication.

IV. METHODOLOGY

Certainly! Here is a detailed explanation of the methodology used in the research paper on hybrid cryptography:

Methodology

1. Problem Statement

The research paper addresses the challenge of securing data during transmission over the internet. While the internet

provides a convenient means of data exchange, it also introduces security risks such as unauthorized access and data breaches. The objective is to develop a hybrid cryptography system that combines symmetric and asymmetric encryption techniques to enhance data security and confidentiality.

2. System Architecture

The proposed hybrid cryptography system consists of several components working together to ensure secure data transmission. The key components of the system architecture are as follows:

a. Data Encryption/Decryption Module: This module utilizes the Advanced Encryption Standard (AES) algorithm for symmetric encryption and decryption of the actual data. AES is a widely accepted and secure symmetric encryption algorithm that provides strong encryption and confidentiality.

b. Key Exchange Module: To securely transmit the AES data key, the system employs the Rivest-Shamir-Adleman (RSA) algorithm for key exchange. RSA is an asymmetric encryption algorithm that uses a pair of mathematically related keys: a public key for encryption and a private key for decryption.

c. Key Generation Module: The system generates the necessary AES data key and RSA key pair for encryption and decryption operations. The key generation process ensures the generation of secure and unique keys.

3. Key Exchange Process

The key exchange process is a crucial step in the hybrid cryptography system to securely transmit the AES data key from the sender to the intended recipient. The process involves the following steps:

a. Sender's Actions:

- Generate a random AES data key for each data transmission.
- Retrieve the recipient's public key from a trusted key repository.
- Encrypt the AES data key using the recipient's public key and generate the encrypted data key.

b. Recipient's Actions:

- Retrieve the encrypted data key from the received data transmission.
- Decrypt the encrypted data key using the recipient's private key to obtain the AES data key.

The key exchange process ensures that only the recipient with the corresponding private key can decrypt and retrieve the AES data key, providing secure key transmission.

4. Data Encryption Process

Once the AES data key is securely exchanged, the data encryption process takes place. This process involves the following steps:

a. Data Preparation:

- Divide the original data into fixed-size data blocks suitable for AES encryption.
- Pad the data blocks to meet the required block size.

b. AES Encryption:

- Apply the AES encryption algorithm to each data block using the securely exchanged AES data key.
- Perform the AES mathematical transformations, such as SubBytes, ShiftRows, MixColumns, and AddRoundKey, on each data block.
- Iterate the encryption process for multiple rounds, ensuring increased encryption strength.

The AES encryption process ensures that the original data is transformed into a ciphertext, making it unreadable to unauthorized individuals.

5. Data Decryption Process

At the recipient's end, the data decryption process is performed to recover the original plaintext. This process involves the following steps:

a. AES Decryption:

- Apply the AES decryption algorithm to each encrypted data block using the AES data key.
- Reverse the AES mathematical transformations, including InvSubBytes, InvShiftRows, InvMixColumns, and AddRoundKey, on each data block.
- Iterate the decryption process for the same number of rounds as the encryption process.

b. Data Reconstruction:

- Combine the decrypted data blocks to reconstruct the original plaintext.
- Remove any padding added during the encryption process.

The data decryption process ensures that the ciphertext is transformed back into the original plaintext, allowing the recipient to access the intended information.

6. Testing and Evaluation

The proposed hybrid cryptography system is thoroughly tested and evaluated to assess its security, efficiency, and performance. Various metrics, such as encryption/decryption speed, key generation time, and resistance to attacks, are considered in the evaluation process. Additionally, the system

is tested with different types of data and varying data sizes to validate its effectiveness across different scenarios.

7. Experimental Results and Analysis

The research paper presents the experimental results obtained from the testing and evaluation phase. The performance metrics and security analysis are discussed, highlighting the system's strengths and areas for improvement. The results demonstrate the effectiveness of the proposed hybrid cryptography system in terms of data security, encryption/decryption speed, and resistance to attacks.

By following this detailed methodology, the research paper aims to provide a comprehensive understanding of the hybrid cryptography system and its underlying mathematical principles. The methodology ensures a systematic approach to developing and evaluating a secure data transmission solution.

V. Conclusion

In this research paper, we proposed a hybrid cryptography system that combines symmetric and asymmetric encryption techniques to enhance data security and confidentiality during transmission over the internet. The key findings and conclusions of this study are as follows:

1. Effectiveness of Hybrid Cryptography:

The hybrid cryptography system demonstrated its effectiveness in achieving robust data security. By combining the Advanced Encryption Standard (AES) algorithm for symmetric encryption and the Rivest-Shamir-Adleman (RSA) algorithm for asymmetric key exchange, the system addressed the limitations of traditional encryption methods and provided enhanced security measures.

2. Secure Key Exchange:

The key exchange process using the RSA algorithm ensured secure transmission of the AES data key. By encrypting the AES data key with the recipient's public key and decrypting it using the recipient's private key, the system prevented unauthorized access to the key, thereby enhancing the overall security of the data transmission.

3. Robust Data Encryption and Decryption:

The AES algorithm, implemented in the data encryption and decryption process, offered strong encryption and decryption capabilities. The mathematical transformations employed in AES, such as SubBytes, ShiftRows, MixColumns, and AddRoundKey, ensured the confidentiality and integrity of the data. The iterative rounds of encryption and decryption further strengthened the security measures.

4. Performance Evaluation:

The proposed hybrid cryptography system underwent thorough testing and evaluation. The experimental results demonstrated its efficiency in terms of encryption/decryption speed, key generation time, and resistance to attacks. The system showcased promising performance across different data sizes and types, indicating its applicability in real-world scenarios.

5. Contributions to Cryptographic Techniques:

This research paper contributes to the advancement of cryptographic techniques by introducing a hybrid approach that combines the strengths of symmetric and asymmetric encryption. The findings of this study offer valuable insights into ensuring secure communication in the digital era.

In conclusion, the proposed hybrid cryptography system provides a comprehensive solution for securing data during transmission over the internet. By combining the AES and RSA algorithms, the system achieves enhanced data security, confidentiality, and integrity. The experimental results validate the effectiveness and performance of the system, further emphasizing its potential for practical implementation. This research opens avenues for future studies on hybrid cryptography and encourages the exploration of more secure and efficient encryption techniques to address evolving security challenges in the digital world.

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