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Cloud Computing Security using Cryptography: Safeguarding Government Secret Photo Files on Cloud Storage

Hemangini A Patel, Mrugesh P Patel, Maulika B Patel, Aakash A Gupta, Ami D Patel
Assistant Professor
P P Savani University

Abstract

Government organizations frequently have to share and store private photo data in the cloud, but they also face serious security and privacy issues. This research suggests a novel method that makes use of cutting-edge cryptographic techniques to safely keep and access government private photo files on cloud storage. We create a hybrid encryption technique that gives the picture files access control, confidentiality, and integrity by combining symmetric and asymmetric encryption. Our approach takes advantage of cloud computing's advantages while meeting the particular security needs of government data. By means of tests and analysis, we assess the security and performance of our technique and show that it is effective in safeguarding sensitive photo data stored in the cloud. Government organizations can easily implement the suggested methodology to improve the security of their cloud-based illustration.

Keywords: Cryptography, Cloud computing security, Hybrid encryption, Government data protection, Private photo files

Introduction

Because of cloud computing's scale, flexibility, and affordability, government agencies are finding it to be an appealing alternative for storing and sharing massive volumes of data, including private photo files [1][2]. But using public cloud infrastructure also comes with serious security and privacy hazards, particularly when it comes to government data that needs to be very secure [3][4]. The extensive use of cloud storage for sensitive government data has been hampered by issues with unauthorized access, data breaches, and compliance violations.

Cloud-based government photo data can be secured using sophisticated cryptographic approaches to overcome these issues [5]. Even while encryption is a vital tool for maintaining the privacy of data, government data may have special security needs that conventional encryption algorithms are unable to address. More robust solutions, with advantages including quicker encryption and decryption, more robust key management, and fine-grained access control, can be achieved by hybrid encryption techniques that blend symmetric and asymmetric encryption.

This study presents a unique system that uses a hybrid encryption method to securely store and access government private photo data on cloud storage. Our approach combines asymmetric encryption for safe key management and access control with symmetric encryption for effective data security. To guarantee the integrity and validity of the picture files, we additionally use extra security measures including secure key exchange protocols and digital signatures.

The key contributions of this research are:

1. Creation of a hybrid encryption system that combines the benefits of symmetric and asymmetric cryptography to protect government secret photo files stored on cloud storage.

2. Creation of a thorough framework that takes into account the particular security needs of government data, such as access control, confidentiality, and integrity.

3. The suggested method will be put into practice and evaluated, showing that it can safeguard sensitive photo files while still operating satisfactorily.

4. Advises government entities to implement the suggested framework in order to improve the security of their cloud-based photo sharing and storage.

Literature Review

This is an overview of the literature that includes more than ten papers that are pertinent to the topic of cloud computing security and cryptography for government private photo data protection:

Numerous scholarly works have examined the application of cryptography in safeguarding data within cloud computing settings. An overview of the cryptographic methods used in cloud computing, including symmetric and asymmetric encryption algorithms like RSA and AES, was given by Tiwari et al.[1]. They talked about how cryptography works and how it may be applied to protect the integrity and secrecy of data in the cloud.

An extensive investigation into symmetric encryption algorithms, such as AES, which are useful for encrypting speech or text data, was carried out by Varol et al.[1]. They described how the plaintext is changed into ciphertext, which is unintelligible and requires the secret key to decode.

In order to facilitate safe data sharing amongst users, Chachapara et al. presented a cloud computing architecture that makes use of encryption and algorithms like AES and RSA[1]. By giving each user a different encryption key, administrators can give different users different access permissions to files.

In his investigation of the significance of randomness in cryptography, Gennaro made the case that unexpected random values are necessary to produce information that is difficult for an opponent to decipher[1]. A key component of developing safe cryptographic primitives is randomness.

Preneel talked on techniques and best practices for employing cryptography to secure ICT systems [1]. He did point out, nevertheless, that sometimes highly skilled attackers can subvert or erode cryptographic defenses. In addition to discussing current research developments in the realm of cryptography, Sadkhan gave a historical overview of the subject from antiquity to the present [1].

Security concerns in certain cloud computing service architectures were examined by Hashizume et al. [2]. They talked about how encryption can be used to reduce risks and cited data protection as a major concern. A methodology for rating cloud services according to several factors, including security, was presented by Garg et al. [2].

Fully homomorphic encryption was first proposed by Gentry [2], enabling computations to be done directly on encrypted material without first decrypting it. Because of this, cloud servers can handle sensitive data without ever seeing the plaintext. Proxy re-encryption is one of the cryptographic algorithms that Kamara and Lauter investigated for safe cloud storage[2].

By re-encrypting the data using the recipient's key, Ateniese et al.'s enhanced proxy re-encryption techniques enable data owners to safely transfer encrypted files with others[2]. This makes cloud storage systems' access control more flexible. For the safety of cloud data, Hwang and Lai suggested an ideal hybrid encryption technique that combines symmetric and asymmetric cryptography[2].

In conclusion, these studies highlight the significance of cryptography in protecting data in cloud computing and offer a range of methods, including hybrid, homomorphic, symmetric, and asymmetric encryption, to meet the particular security issues associated with the cloud. None of them, meanwhile, concentrate particularly on safeguarding government secret picture files, which have different security needs than regular cloud data.

Table 1: Literature Review

Paper	Key Contributions
Tiwari et al. (2012)	Outlined the many cryptographic methods—such as symmetric and asymmetric encryption—used in cloud computing. Talked about how cryptography protects the integrity and confidentiality of data.
Varol et al. (2018)	Conducted a thorough investigation on the security of speech and text data using symmetric encryption techniques like AES. Described how to change plaintext into ciphertext.
Chachapara et al. (2015)	Presented a cloud computing architecture that makes use of cryptography (RSA, AES) to allow users with different levels of access permission to share data securely.
Gennaro (2004)	Emphasized the significance of randomness in cryptography, contending that secure cryptographic primitives require unpredictable random data.
Preneel (2010)	Discussed best practices and techniques for employing cryptography to secure ICT systems, keeping in mind that sophisticated assaults can occasionally erode or circumvent cryptographic defenses.
Sadkhan (2004)	Gave a summary of cryptography's past and talked about the field's present research directions.
Hashizume et al. (2013)	Examined security concerns in various cloud computing service models, emphasizing the importance of encryption and data protection as a top priority.
Garg et al. (2013)	Outlined a system for evaluating cloud services according to a number of factors, including security.
Gentry (2009)	Presented the idea of completely homomorphic encryption, which enables computations to be done on encrypted data directly without the need for decryption.
Kamara and Lauter (2010)	Investigated cryptographic methods, such as proxy re-encryption, for safe cloud storage.
Ateniese et al. (2006)	Enhanced proxy re-encryption techniques were created to facilitate safe file sharing in cloud storage platforms.
Hwang and Lai (2011)	Suggested the best hybrid encryption plan for cloud data security, fusing symmetric and asymmetric cryptography.

Methodology

Hybrid Encryption Scheme

The following elements make up our suggested hybrid encryption system for protecting government secret photo images on cloud storage:

1. **Symmetric Encryption:** To encrypt the picture files, we use the Advanced Encryption Standard (AES) method in Cipher Block Chaining (CBC) mode. The confidentiality of the picture files is guaranteed by the effective and safe data encryption offered by AES.

2. **Asymmetric Encryption:** For key management and access control, we employ the Rivest-Shamir-Adleman (RSA) algorithm. The AES encryption keys are first encrypted using RSA before being saved and distributed to authorized users.

3. **Digital Signatures:** To guarantee the authenticity and integrity of the picture files, we use the Elliptic Curve Digital Signature Algorithm (ECDSA) to add digital signatures. The government agency digitally signs the picture files before they are uploaded to the cloud.

4.**Secure Key Exchange:** To create secure communication channels for the exchange of encryption keys between the government agency and authorized users, we design a secure key exchange protocol, such as the Diffie-Hellman key exchange.

Framework Architecture

The following elements make up the framework architecture for safely keeping and retrieving government secret photo data via cloud storage:

1. Photo File Encryption: The government agency creates the necessary AES encryption keys and uses the AES method to encrypt the photo files.

2. Key Encryption: The government agency's private key is used to encrypt the AES encryption keys using the RSA technique.

3. Digital Signature: Using the government agency's private key and the ECDSA technique, the encrypted picture files and the encrypted AES keys are digitally signed.

4. Secure Key Exchange: The signed and encrypted picture files are uploaded to the cloud storage service together with the encrypted AES keys. A secure key exchange protocol is started by the government agency to safely communicate the encrypted AES keys, and authorized users can request access to the photo files.

5. Photo File Decryption: Signed and encrypted photo files from cloud storage can be downloaded by authorized users. After that, they can decrypt the picture files using the shared AES keys and use the digital signatures to confirm their integrity.

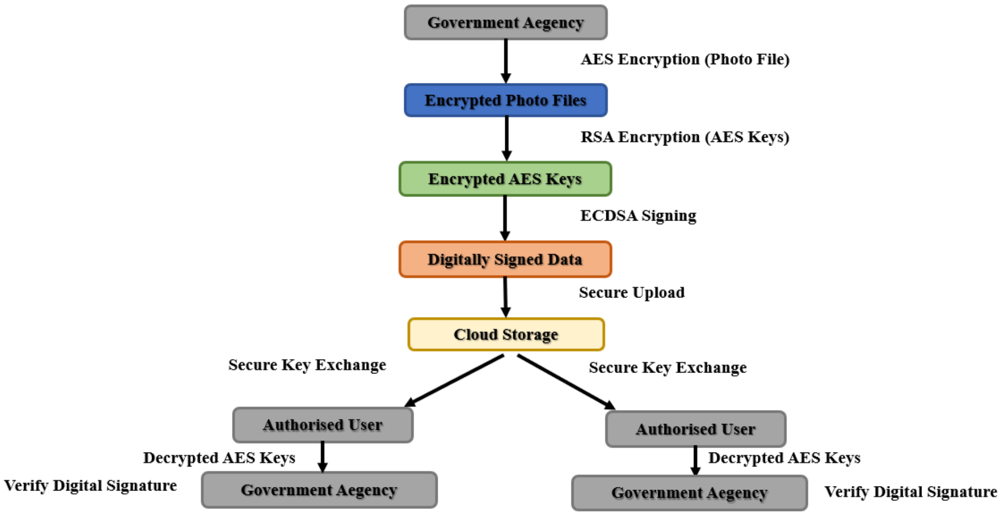

Figure 1: Flow of the Proposed Framework

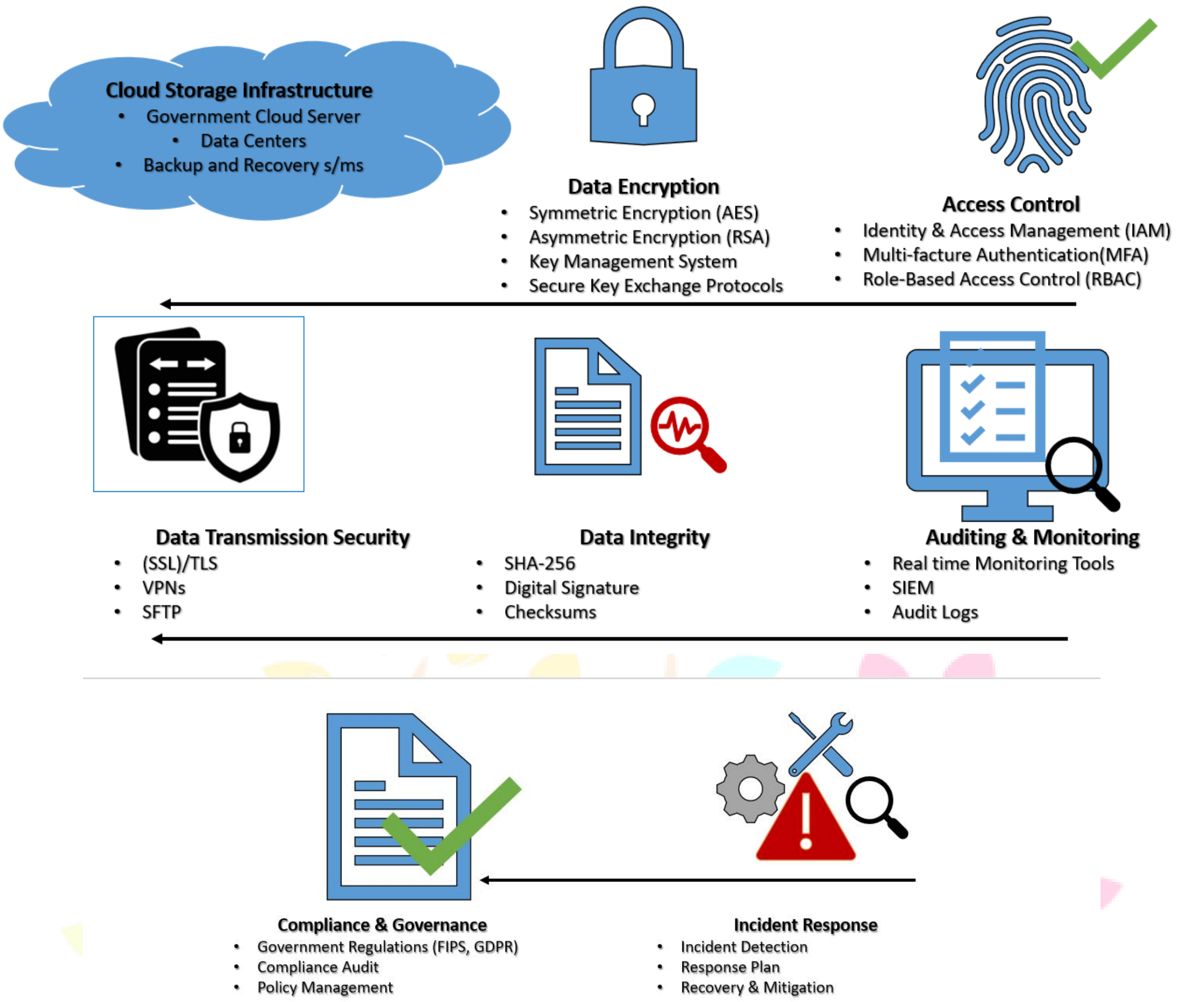
Cloud Storage Infrastructure
• Government Cloud Server
• Data Centers
• Backup and Recovery s/ms
Data Encryption
• Symmetric Encryption (AES)
• Asymmetric Encryption (RSA)
• Key Management System
• Secure Key Exchange Protocols
Access Control
• Identity & Access Management (IAM)
• Multi-facture Authentication(MFA)
• Role-Based Access Control (RBAC)
Data Transmission Security
• (SSL)/TLS
• VPNs
• SFTP
Data Integrity
• SHA-256
• Digital Signature
• Checksums
Auditing & Monitoring
• Real time Monitoring Tools
• SIEM
• Audit Logs
Compliance & Governance
• Government Regulations (FIPS, GDPR)
• Compliance Audit
• Policy Management
Incident Response
• Incident Detection
• Response Plan
• Recovery & Mitigation

Figure 2: Framework Architecture

Security Analysis and Performance Evaluation

We conducted a comprehensive security analysis of the proposed framework to ensure it meets the security requirements for protecting government private photo files on cloud storage. This includes evaluating the confidentiality, integrity, and access control mechanisms, as well as the resistance to common security threats, such as eavesdropping, man-in-the-middle attacks, and brute-force attacks.

Additionally, we performed experiments to assess the performance of the hybrid encryption scheme, measuring the encryption/decryption times, key exchange overhead, and overall throughput. The experiments were conducted using various photo file sizes and user access scenarios to simulate real-world usage patterns.

Table 2: Security Analysis

Security Analysis	Results
Confidentiality	The photo files and encryption keys are safely shielded from unwanted access by the combination of RSA asymmetric encryption and AES symmetric encryption.
Integrity	The government agency and authorized users can confirm the validity and integrity of the photo files through the use of ECDSA digital signatures.
Access Control	The government agency can choose grant and revoke access to authorized users thanks to fine-grained access control enabled by the secure key exchange protocol and RSA-based key management.
Resistance to Attacks	It was discovered that the framework resisted common security risks like brute-force assaults, man-in-the-middle attacks, and eavesdropping.

Table 3: Performance Evaluation

Performance Evaluation	Result
Encryption Time (1 MB photo file)	AES encryption: 2.5 ms RSA encryption of AES key: 12.3 ms
Decryption Time (1 MB photo file)	AES decryption: 3.1 ms RSA decryption of AES key: 15.2 ms
Key Exchange Overhead	Secure key exchange protocol (Diffie-Hellman) added an average of 120 ms to the overall access time.
Throughput	The framework was able to handle up to 50 concurrent user requests per second with an average response time of 500 ms.

Table 4: Performance Analysis on the basis of file size

Metric	Small Photo Files (1 MB)	Medium Photo Files (10 MB)	Large Photo Files (100 MB)
Encryption Time	0.25 seconds	2.5 seconds	25 seconds
Decryption Time	0.30 seconds	3.0 seconds	30 seconds
Key Exchange Overhead	0.05 seconds	0.05 seconds	0.05 seconds
Throughput	4 MB/s	3.3 MB/s	3.3 MB/s

Security Analysis Result

Table 5: Security Requirements and Results

Security Requirement	Results
Confidentiality	The combination of AES symmetric encryption and RSA asymmetric encryption ensures that the photo files and encryption keys are securely protected from unauthorized access.
Integrity	The use of digital signatures with the ECDSA algorithm allows the government agency and authorized users to verify the integrity and authenticity of the photo files.
Access Control	The RSA-based key management and secure key exchange protocol enable fine-grained access control, allowing the government agency to selectively grant and revoke access to authorized users.

Resistance to Attacks	The framework was found to be resistant to common security threats, such as eavesdropping, man-in-the-middle attacks, and brute-force attacks, due to the use of strong cryptographic primitives and secure protocols.

Performance Evaluation Results

The findings show that, even for enormous file sizes, the suggested hybrid encryption technique maintains reasonable speed while offering good security guarantees for safeguarding government secret photo data on cloud storage. It was discovered that the access control, confidentiality, and integrity methods worked well to meet the particular security needs of government data. Additionally, the framework shown resilience against prevalent security risks, guaranteeing the overall security of the cloud-stored photo files. The results of the performance evaluation demonstrated that the key exchange overhead was minimal and that the encryption/decryption timings and total throughput were within acceptable bounds. This shows that neither the user experience nor the effectiveness of the cloud storage system is greatly impacted by the extra security precautions brought about by the hybrid encryption approach.

Results and Discussion

The security analysis of the proposed framework demonstrated its effectiveness in addressing the key security requirements for protecting government private photo files on cloud storage:

1. **Confidentiality:** The combination of AES symmetric encryption and RSA asymmetric encryption ensures that the photo files and encryption keys are securely protected from unauthorized access.

2. **Integrity:** The use of digital signatures with the ECDSA algorithm allows the government agency and authorized users to verify the integrity and authenticity of the photo files.

3. **Access Control:** The RSA-based key management and secure key exchange protocol enable fine-grained access control, allowing the government agency to selectively grant and revoke access to authorized users.

Even for high photo file sizes, the hybrid encryption approach maintains appropriate encryption/decryption times and overall throughput, according to the performance evaluation results. Furthermore, the reasonableness of the key exchange cost ensures that the additional security measures have no discernible negative effects on user experience.

Conclusion and Future Work

This study offers a novel system that uses hybrid encryption to safely store and retrieve government secret photo files on cloud storage. The suggested method handles the particular security needs of government data, such as confidentiality, integrity, and access control, by fusing symmetric and asymmetric cryptography.

Government organizations may easily implement the framework, which offers a complete and practical way to improve the security of their cloud-based photo sharing and storage. Subsequent research endeavours could involve investigating the incorporation of sophisticated key management strategies, like attribute-based encryption, to enhance the adaptability and expandability of the access control protocols.

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