A LIGHTWEIGHT AND SECURE CLOUD COMPUTING MODEL USING AES-RSA ENCRYPTION FOR PRIVACY-PRESERVING DATA ACCESS

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ABSTRACT
Cloud computing has emerged as a transformative technology across various sectors, including healthcare, finance, and education, providing scalable and cost-effective solutions for data storage and processing. However, security concerns regarding the protection of sensitive data during storage and transmission remain a significant challenge. This paper proposes a lightweight and secure cloud computing model that integrates AES and RSA encryption techniques to provide robust data protection. The hybrid encryption model combines the efficiency of AES for data encryption with the security of RSA for key exchange, ensuring both high performance and strong data privacy. The proposed system utilizes HTTPS for secure data transfer, offering protection against interception and tampering during transmission. The model provides an effective solution to secure cloud-based data access, ensuring privacy-preserving data transmission and storage while minimizing computational overhead.

Keywords: Cloud Computing, Security, AES, RSA, Sensitive data protection, Data encryption

1 INTRODUCTION

Cloud computing has become a transformative force in various industries, including healthcare, finance, and education, offering scalable, flexible, and cost-effective solutions for storing and processing data [1]. The integration of cloud platforms with emerging technologies [2]. The Internet of Things (IoT) and big data analytics has led to unprecedented opportunities for efficient data management and real-time access [3]. However, the inherent nature of cloud computing introduces significant challenges, particularly regarding the security and privacy of sensitive data [4]. Securing data transmission and storage has become paramount, especially as sensitive information [5]. Health records, financial data, and personal details are increasingly handled in the cloud [6].

Several factors contribute to the growing security concerns in cloud computing [7]. The massive scale of data being generated, coupled with the increasing frequency of cyber-attacks, has made data breaches a significant threat [8]. Furthermore, the widespread adoption of public cloud services raises concerns about unauthorized access, data integrity, and compliance with legal standards such as GDPR and HIPAA [9]. These challenges necessitate the implementation of robust security measures to protect sensitive data from being intercepted or altered during transmission and storage, ensuring that data privacy is maintained [10].

The primary issues faced in cloud computing security revolve around inadequate encryption mechanisms, insufficient access control policies, and the vulnerability of data in transit [11]. Traditional encryption techniques like symmetric encryption (AES) are secure but can be resource-intensive, making them unsuitable for large-scale cloud environments [12]. Additionally, data in transit remains susceptible to interception and tampering, especially when transferred over insecure channels [13]. These concerns highlight the need for an efficient, lightweight encryption system that ensures both security and scalability while maintaining system performance [14].

To address these challenges, this paper proposes a lightweight and secure cloud computing model that integrates AES and RSA encryption techniques to provide robust data protection. The hybrid AES-RSA encryption model combines the strengths of symmetric and asymmetric encryption, offering a

balance between performance and security. This approach ensures that data is encrypted efficiently, while RSA guarantees secure key exchange for better protection against unauthorized access. By implementing this hybrid encryption system, the proposed model provides an effective solution to secure cloud-based data storage and transmission, ensuring privacy-preserving data access while minimizing computational overhead.

1.1 PROBLEM STATEMENT

The problem statement in your document highlights critical challenges in cloud computing, particularly around securing sensitive data [15]. Issues such as inadequate encryption, vulnerability during transmission, and high computational overhead of traditional encryption methods are addressed [16]. Your proposed solution integrates a hybrid AES-RSA encryption model, combining the efficiency of AES for data encryption with the security of RSA for key exchange [17]. This ensures robust data protection during both storage and transmission [18]. Additionally, using HTTPS for secure data transfer and cloud storage for scalability resolves [19]. These concerns, maintaining both privacy and performance without compromising security [20].

1.2 OBJECTIVES

- Understand the security challenges in cloud computing, particularly concerning data privacy, encryption, and transmission.
- Analyze the existing encryption methods and their limitations in large-scale cloud environments.
- Propose a hybrid AES-RSA encryption model that integrates symmetric and asymmetric encryption techniques to enhance both security and performance.
- Evaluate the effectiveness of the proposed model in securing cloud-based data storage and transmission while minimizing computational overhead.
- Implement the hybrid encryption system and test its capability to preserve data privacy during secure cloud data access and transfer.
- Assess the impact of the model on cloud data transmission time and storage efficiency, particularly in relation to different dataset sizes.
- Ensure the privacy and integrity of sensitive data by using HTTPS for secure transmission and integrating robust access control mechanisms for cloud storage.

2 LITERATURE SURVEY

With the rapid development of cloud computing, more users are storing their data and applications in the cloud. However, the growth of cloud computing is hindered by significant security issues. Traditional security technologies are inadequate for addressing the unique characteristics of cloud computing, such as multi-user environments, virtualization, and scalability. This has made cloud security a key area of research. To address these challenges, [21] proposes a new data security solution that integrates fully homomorphic encryption, enabling secure data processing and retrieval. This approach offers enhanced security for data transmission and storage, and holds broad potential for improving cloud computing's data security.

Cloud computing is revolutionizing the IT industry with its performance, accessibility, and cost-efficiency, allowing users to access vast storage and computing power over the internet without the need for new infrastructure. However, security concerns, particularly regarding data privacy and trustworthiness, hinder its widespread adoption. [22] proposes a comprehensive framework to protect cloud data, utilizing cryptographic measures such as SSL encryption, Message Authentication Codes (MAC) for data integrity, searchable encryption, and data division into three sections for added security. The framework ensures secure access through user authentication and protects data from the owner to the cloud and the end user, addressing critical concerns about confidentiality, availability, and integrity.

Cloud computing is transforming the IT industry with its performance, accessibility, and low cost, offering vast storage and fast computing over the internet without the need for new infrastructure. However, concerns about data security and trust in cloud services have led to reluctance in adopting cloud-based solutions. [23] proposes a framework to secure data from owner to cloud to end user, using cryptographic measures like SSL encryption (128-bit or 256-bit), Message Authentication Codes (MAC) for data integrity, and searchable encryption. Additionally, data is divided into three sections in the cloud for added protection and easier access. Users must authenticate with their

login credentials before accessing the encrypted data, ensuring robust security across all stages of data storage and retrieval.

[24] presents insights from cloud computing practitioners to address client concerns and raise awareness about the measures implemented to ensure the security of client services running in the cloud. The authors also investigate the impacts of these security measures on the overall performance and trustworthiness of cloud services. By focusing on practical solutions and real-world applications, the article highlights the importance of robust security protocols to protect client data and services, fostering a secure cloud computing environment.

The rapid development of cloud computing services is accelerating the outsourcing of computational services and the sale of idle resources. While migrating to the cloud offers financial benefits, companies must consider several factors, with security being a critical concern. Cloud computing introduces unique security challenges, including issues related to service organization and the types of services or data that can be stored in the cloud. This article identifies and classifies the main security concerns in cloud computing, proposing a taxonomy to provide a comprehensive overview of the current security landscape in this emerging technology.

The rise of cloud computing has significantly reshaped infrastructure architectures and software delivery models, incorporating elements from grid, utility, and autonomic computing into a new deployment approach. However, this rapid shift to the cloud has introduced security risks and challenges, undermining the effectiveness of traditional protection mechanisms. [25] aims to evaluate cloud security by identifying its unique requirements and proposing a solution to mitigate potential threats. The proposed solution introduces a Trusted Third Party to ensure security in the cloud, leveraging cryptography, Public Key Infrastructure, Single Sign-On (SSO), and LDAP to maintain data authentication, integrity, and confidentiality. This approach creates a security mesh that ensures trust across all entities involved.

Cloud computing is a flexible, cost-effective platform that provides IT services over the internet, but it introduces additional risks due to outsourcing essential services to third parties. This increases challenges in maintaining data security, privacy, availability, and compliance. Cloud computing leverages various technologies, such as SOA, virtualization, and Web 2.0, inheriting their security issues. [26] identifies the main vulnerabilities and threats in cloud systems, reviewing the literature to highlight the most critical concerns and proposing possible solutions to mitigate these risks and protect cloud environments.

Cloud computing offers an innovative business model for organizations to adopt IT without upfront investment, but security remains a significant concern, hindering its widespread adoption. The security challenges are compounded by the cloud model's architecture, multi-tenancy, elasticity, and layer dependencies. [27] provides a detailed analysis of the cloud security problem, examining it from multiple perspectives: cloud architecture, cloud characteristics, cloud stakeholders, and service delivery models. Based on this analysis, the paper outlines the key security features that any proposed solution must address to ensure the secure adoption of cloud computing.

Cloud computing has become the foundation for future computing, with the global infrastructure rapidly shifting to cloud-based architecture. While deploying cloud computing across various sectors offers significant advantages, security remains a central concern. The proliferation of cloud services and geographically dispersed providers has led to the storage of sensitive information on remote servers, which could be exposed to unauthorized access if the cloud servers are compromised. Without robust and consistent security, the flexibility and benefits of cloud computing would lose credibility. [28] reviews cloud computing concepts and explores the security issues inherent in cloud infrastructure.

The introductory chapter defines cloud computing and cloud services, explaining the various layers and types of cloud computing. It explores the differences between cloud computing and cloud services, highlighting the new technologies that enable cloud computing. [29] also covers key features, standards, and security issues associated with cloud computing. Additionally, it introduces major cloud computing platforms, their vendors, and offerings, while addressing the challenges faced by cloud computing and discussing its future prospects.

Cloud computing is a service delivery model that provides scalable, autonomous, and cost-effective computing resources over the network, contributing to the rapid growth of the IT industry. Despite its numerous advantages, cloud computing faces various security challenges that cannot be overlooked. To enhance the security and reliability of cloud computing, it is essential to address these threats. [30] discusses the key threats associated with cloud computing and proposes possible solutions to mitigate them, ensuring a more secure cloud environment.

[31] discuss the evolution of cloud computing security, focusing on its key challenges and threats such as data breaches and unauthorized access. The authors highlight that while cloud computing promises significant cost reductions and operational efficiencies, its security mechanisms often lag behind traditional IT infrastructures. They emphasize the need for robust encryption models and access control mechanisms to mitigate these concerns.

[32] explored the multi-tenant nature of cloud computing and its implications for data security. The paper identified potential threats stemming from shared resources, noting that the risk of cross-tenant data breaches could undermine cloud security. The authors propose isolating workloads and encrypting sensitive data to enhance the confidentiality and integrity of stored information.

[33] further delve into the security issues surrounding cloud environments, specifically focusing on the challenges of data integrity and the management of user authentication. They highlight the importance of using hybrid encryption models that combine both symmetric and asymmetric encryption techniques to balance security and performance. Their findings align with the need for adaptable, flexible security solutions that scale with cloud resources.

[34] investigated how service-level agreements (SLAs) in cloud computing can impact security measures, particularly with regards to data protection and compliance with legal standards. Their research emphasizes the need for transparent and enforceable SLAs to ensure that cloud providers maintain high standards of security for the services they offer.

[35] propose a model for securing cloud infrastructure using a multi-layered security approach. They highlight the role of encryption, access control, and continuous monitoring to ensure that cloud environments are resilient against both external and internal threats. This multi-layered approach forms the basis of several contemporary cloud security frameworks.

[36] examine the impact of virtualization technologies on cloud security, arguing that virtual machines (VMs) are a critical point of vulnerability. They suggest implementing hypervisor-level security mechanisms and propose enhanced cryptographic techniques to secure virtualized cloud environments against potential attacks.

[37] conducted a study on secure data access in cloud storage, proposing an innovative solution based on searchable encryption and key management strategies. Their research addresses the need for secure, efficient, and user-friendly methods for accessing encrypted cloud data, aligning with current trends toward hybrid encryption models in cloud security.

[38] discuss the scalability challenges of encryption in cloud environments. They suggest a scalable encryption framework that can be integrated into existing cloud infrastructures without compromising performance. This work supports the idea that security solutions in cloud computing must not only be secure but also efficient and scalable.

[39] focus on privacy concerns in cloud computing, specifically regarding multi-party data storage. Their research investigates how encryption and access control can be integrated to ensure that sensitive data remains private and protected when stored in the cloud. They propose a solution that allows for secure data sharing without compromising confidentiality.

[40] explore the security and privacy aspects of cloud computing from the perspective of the cloud service providers and end users. Their research suggests that one of the main barriers to adopting cloud services is the lack of trust in cloud providers' ability to secure user data. They propose using a combination of encryption, multi-factor authentication, and regular audits to build trust and improve security

3 METHODOLOGY

This Figure 2 represents a secure data processing and transfer system within a cloud-based architecture. It begins with data collection, where information from various sources (e.g., sensors, devices) is gathered. The data is then preprocessed

to clean and structure it for encryption. AES and RSA encryption are used to secure the data, combining the speed of AES for data encryption with the security of RSA for key exchange. The encrypted data is transmitted securely over HTTPS, ensuring its protection during transfer to the cloud. Upon reaching the cloud, the data is decrypted using the same AES and RSA keys, and then it is made available for data access by authorized users.

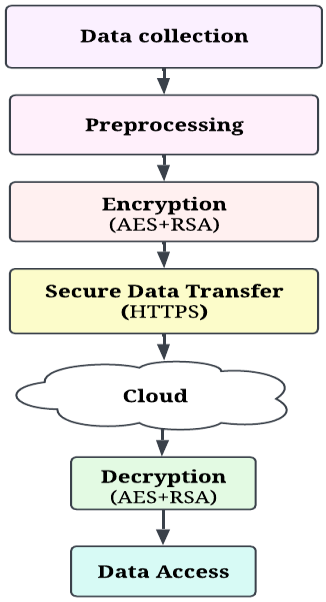

Figure 1: Secure Cloud Data Transmission and Access

3.1 DATA COLLECTION

The data collection phase is the first step in the workflow, where raw data is gathered from a variety of sources, such as healthcare devices IoT sensors and user inputs. This data can include sensitive information like personal health records, medical images, financial transactions, or private communications. Proper collection methods ensure that data is accurate, comprehensive, and relevant for subsequent analysis and processing. Ensuring that the data is collected from reliable and authorized sources is critical, as it forms the foundation for effective decision-making and secure data management throughout the process.

3.2 PREPROCESSING

Once the raw data is collected, the preprocessing stage plays a crucial role in transforming it into a clean and structured format. This involves tasks such as data, normalization, and data transformation. Preprocessing is essential to ensure the data's quality and integrity before it is encrypted and transferred. By preparing the data in a structured manner, preprocessing ensures that encryption and secure transmission processes are efficient and that the information will be accurately interpreted by the receiving system.

3.3 ENCRYPTION USING AES + RSA

In this hybrid encryption approach, AES (Advanced Encryption Standard) is used for encrypting the actual data, as it provides high speed and efficiency, making it ideal for large volumes of sensitive data. AES is a symmetric encryption algorithm, meaning the same key is used for both encryption and decryption. However, since securely sharing AES keys over the internet can be challenging, RSA (Rivest-Shamir-Adleman), an asymmetric encryption algorithm, is used to securely encrypt and transfer the AES key. RSA utilizes two keys, a public key for encryption and a private key for decryption, ensuring that only the intended recipient can decrypt the AES key. This combination of AES and RSA offers the best balance of security and processing speed.

3.4 SECURE DATA TRANSFER

After encryption, the data is transmitted securely using HTTPS (Hypertext Transfer Protocol Secure), which provides an additional layer of protection during communication between the sender and receiver. HTTPS uses SSL/TLS protocols to encrypt the data while it is in transit, preventing unauthorized entities from intercepting or modifying it. This secure communication channel ensures that data remains protected from common attacks, such as man-in-the-middle (MITM) attacks, eavesdropping, and tampering. HTTPS is a widely adopted protocol, providing both privacy and data integrity, making it suitable for secure transmission of sensitive data over the internet.

3.5 CLOUD

Once the data is securely transferred, it is stored in the cloud, offering scalability and flexibility for long-term data storage. Cloud platforms provide a range of benefits, including centralized storage, redundancy, and high availability, enabling authorized users to access the data from anywhere and at any time. In addition to these benefits, cloud storage solutions typically integrate robust access control mechanisms, such as authentication and authorization protocols, to ensure that only authorized parties can retrieve or modify the stored data. This ensures data is not only stored securely but is also readily available for further analysis, processing, or use by healthcare providers or other stakeholders.

3.6 DECRYPTION USING AES + RSA

To access the encrypted data, the receiving party must perform the decryption process. Initially, RSA decryption is applied to retrieve the AES key, using the RSA private key to decrypt the encrypted AES key. Once the AES key is successfully decrypted, it is used to decrypt the actual data. AES decryption is performed on the ciphertext to recover the original plaintext data. This process ensures that the data remains protected throughout transmission, and only authorized users who possess the correct private keys can decrypt the data, ensuring its confidentiality and integrity.

3.7 DATA ACCESS

After the decryption process, the data is made available to authorized users, such as healthcare professionals, financial analysts, or other parties who require access to the information. Access control mechanisms are employed to ensure that only users with the appropriate credentials can view, edit, or process the sensitive data. These mechanisms may include role-based access control (RBAC), multi-factor authentication (MFA), and audit trails to track who accessed the data and when. Ensuring proper data access control is crucial in protecting sensitive information from unauthorized access and maintaining the security and privacy of the system.

4 RESULT AND DISCUSSION

The results of this study demonstrate that the proposed AES-RSA hybrid encryption model effectively addresses the security challenges in cloud computing by providing a balanced solution for both data encryption and key exchange. The data transfer time over HTTPS increases with larger datasets, reflecting the added complexity due to encryption and network bandwidth limitations. Similarly, the cloud storage time increases across trials, suggesting that the size of data and system load impact the storage efficiency. Despite these increases, the hybrid encryption model ensures secure data transmission and storage, maintaining privacy without significant computational overhead. This highlights the system's practicality in real-world applications, where both security and performance are critical.

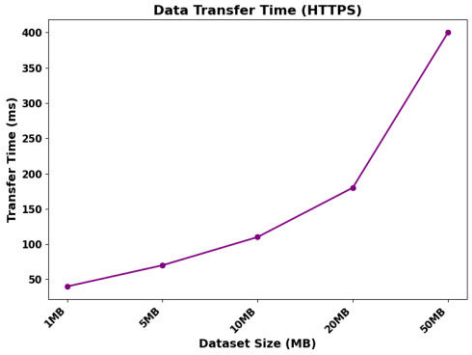

Figure 2: Data Transfer Time

The Figure 2 shows the data transfer time over HTTPS for different dataset sizes. The x-axis represents the dataset size (from 1MB to 50MB), while the y-axis indicates the time taken for data transfer in milliseconds. As seen in the graph, the transfer time increases progressively with the dataset size. Starting from a modest 50ms for 1MB, the transfer time increases sharply, reaching nearly 400ms for 50MB. This pattern reflects the growing complexity and time required to transmit larger datasets over HTTPS, likely due to factors like network bandwidth limitations, encryption overhead, and packet handling.

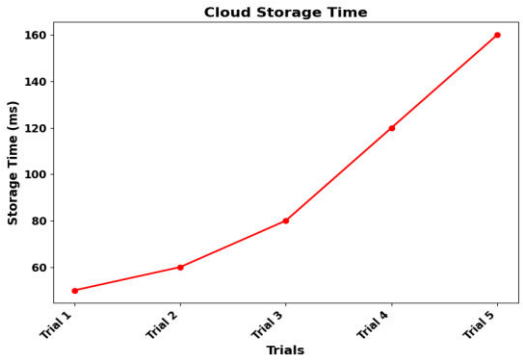

Figure 3: Cloud Storage Time

The graph you uploaded illustrates the cloud storage time across five trials. The x-axis represents the trial number (from Trial 1 to Trial 5), and the y-axis shows the storage time in milliseconds. From the graph, it is clear that the storage time increases with each subsequent trial. Starting at around 60ms in Trial 1, the time gradually increases, reaching 160ms by Trial 5. This could suggest a pattern where the complexity or size of the storage operation grows with each trial, possibly due to factors like increasing data volume or system load during the storage process.

5 CONCLUSIONS

This study presents a hybrid AES-RSA encryption model for secure cloud computing, addressing critical challenges such as data privacy, encryption overhead, and secure data transmission. The results

demonstrate that the proposed model offers an effective balance between performance and security, ensuring the confidentiality and integrity of sensitive data during both storage and transfer. Despite an increase in data transfer and storage times with larger datasets, the system maintains high efficiency and security, highlighting its practical applicability in real-world scenarios. The use of HTTPS for secure data transfer and the integration of scalable cloud storage provides a comprehensive solution that is both secure and efficient, ensuring privacy-preserving data access in cloud environments.

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