INFOMANIA: THE RESEARCH JOURNAL
Volume 2, Issue 3, May - June 2026
https://infomaniajournal.com **ISSN:3108-0006**

Cloud Data Security Impact on Financial Transactions Using Advanced Encryption Algorithms

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Abstract

Cloud computing has revolutionized the financial sector by enabling scalable, cost-effective, and real- time transaction processing. However, the increasing volume of sensitive financial data stored and transmitted through cloud environments raises significant security concerns. Cyberattacks, unauthorized access, data breaches, and financial fraud threaten the confidentiality and integrity of transaction data. Encryption algorithms play a vital role in protecting financial information during storage and transmission. This paper examines the impact of cloud data security on financial transactions and proposes a secure framework utilizing Advanced Encryption Standard (AES), Rivest–Shamir–Adleman (RSA), and Elliptic Curve Cryptography (ECC) algorithms. The proposed architecture ensures confidentiality, integrity, authentication, and regulatory compliance while maintaining transaction efficiency. The study highlights the effectiveness of hybrid encryption approaches in securing modern cloud-based financial systems.

Keywords: Cloud Security, Financial Transactions, Encryption Algorithms, AES, RSA, ECC, Data Privacy, Cloud Computing, Cybersecurity.

1. Introduction

The financial industry has rapidly adopted cloud computing technologies to enhance operational efficiency, reduce infrastructure costs, and provide seamless digital banking services [1], [2]. Cloud platforms facilitate online banking, mobile payments, digital wallets, stock trading, and interbank fund transfers while providing scalability and flexibility for financial institutions [2], [5]. Despite these benefits, the migration of sensitive financial data to cloud environments introduces several security challenges, including cyberattacks, data breaches, and unauthorized access [6], [12].

Financial transactions involve confidential customer information, account details, payment credentials, and transaction records that must be protected against evolving cyber threats [12], [16]. Data breaches can lead to financial losses, reputational damage, and regulatory penalties [13]. Therefore, robust encryption mechanisms are essential to safeguard financial information throughout its lifecycle [7], [10].

2. Literature Review

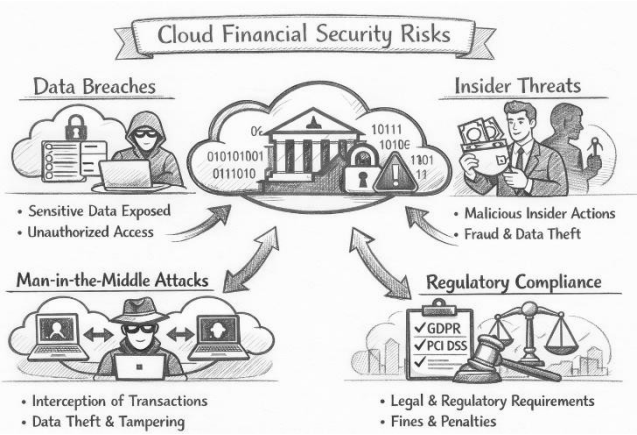
Recent studies have emphasized the increasing importance of cloud security in modern financial systems as organizations continue to migrate banking and payment services to cloud platforms. Cloud-based banking systems offer significant advantages, including scalability, flexibility, cost efficiency, and real-time access to financial services. However, these benefits are accompanied by growing cybersecurity challenges such as data breaches, unauthorized access, and sophisticated cyberattacks.

To address these concerns, various encryption techniques have been adopted in financial applications. The Advanced Encryption Standard (AES) is widely used for securing stored financial data because of its high processing speed, strong security features, and efficient performance. RSA encryption is commonly employed for secure key exchange and digital signature generation, enabling secure communication and authentication between users and cloud servers. Similarly, Elliptic Curve Cryptography (ECC) provides a high level of security with smaller key sizes, making it particularly suitable for resource-constrained environments such as mobile banking applications.

Researchers have also proposed hybrid encryption approaches that combine symmetric encryption algorithms such as AES with asymmetric algorithms such as RSA and ECC. These hybrid models enhance both security and system performance by leveraging the strengths of each cryptographic technique. Furthermore, blockchain technology has emerged as a promising solution for improving transparency, traceability, and resistance to data tampering within financial ecosystems.

Despite these technological advancements, many existing solutions primarily focus on individual security mechanisms rather than providing a comprehensive and integrated security framework. There remains a significant research gap in developing unified architectures that effectively combines encryption, authentication, continuous monitoring, fraud detection, and regulatory compliance management to ensure end-to-end security for cloud-based financial transactions.

3. Challenges in Cloud-Based Financial Transactions



Cloud-based financial systems offer numerous benefits, including scalability, accessibility, and cost efficiency. However, they also face several security and operational challenges that can affect the confidentiality, integrity, and reliability of financial transactions.

Data Breaches: Data breaches represent one of the most significant threats to cloud-based financial systems. Unauthorized access to cloud databases can expose sensitive customer information, banking credentials, payment details, and transaction records. Such incidents may result in substantial financial losses, legal consequences, and damage to the reputation of financial institutions.

Insider Threats: Insider threats occur when employees, contractors, or system administrators with authorized access intentionally or unintentionally misuse sensitive financial information. These threats can lead to data leakage, fraudulent activities, privacy violations, and unauthorized disclosure of confidential customer data, ultimately weakening the security posture of financial organizations.

Man-in-the-Middle (MITM) Attacks: Man-in-the-Middle attacks occur when cybercriminals intercept communications between users and cloud servers during transaction processing. By capturing or modifying data in transit, attackers can gain access to sensitive financial information, manipulate transaction details, or steal customer credentials. Such attacks pose a serious risk to the confidentiality and security of cloud-based financial transactions.

Regulatory Compliance: Financial institutions operating in cloud environments must adhere to various regulatory and security standards, including PCI-DSS, GDPR, and RBI cybersecurity guidelines. Compliance with these regulations is essential for protecting customer data and ensuring secure financial operations. Failure to meet regulatory requirements can result in legal penalties, financial sanctions, and a loss of customer trust.

Data Integrity Issues: Maintaining data integrity is critical in financial transaction systems. Unauthorized modification, corruption, or tampering of transaction records can lead to inaccurate account balances, fraudulent transactions, financial disputes, and operational disruptions. Ensuring the accuracy and consistency of financial data is therefore essential for maintaining customer confidence and the reliability of digital banking services.

Overall, addressing these challenges requires the implementation of robust security measures, including encryption, authentication mechanisms, access control policies, continuous monitoring, and regulatory compliance frameworks to ensure secure and trustworthy cloud-based financial transactions.

4. Proposed Secure Cloud Framework

4.1 System Architecture: The proposed secure cloud architecture for financial transactions is organized into four interconnected layers that collectively ensure confidentiality, integrity, authentication, and efficient transaction processing within cloud environments.

The User Layer serves as the interface between customers and financial services. It includes mobile banking applications, internet banking portals, payment gateways, and ATM networks through which users initiate and manage financial transactions. This layer provides convenient access to banking services while enabling seamless communication with the underlying security infrastructure.

The **Security Layer** is responsible for verifying the identity of users and protecting access to financial resources. It incorporates Multi-Factor Authentication (MFA), digital signatures, and Identity and Access Management (IAM) mechanisms. These security controls ensure that only authorized individuals can access financial services and perform transactions, thereby reducing the risk of unauthorized access and fraud.

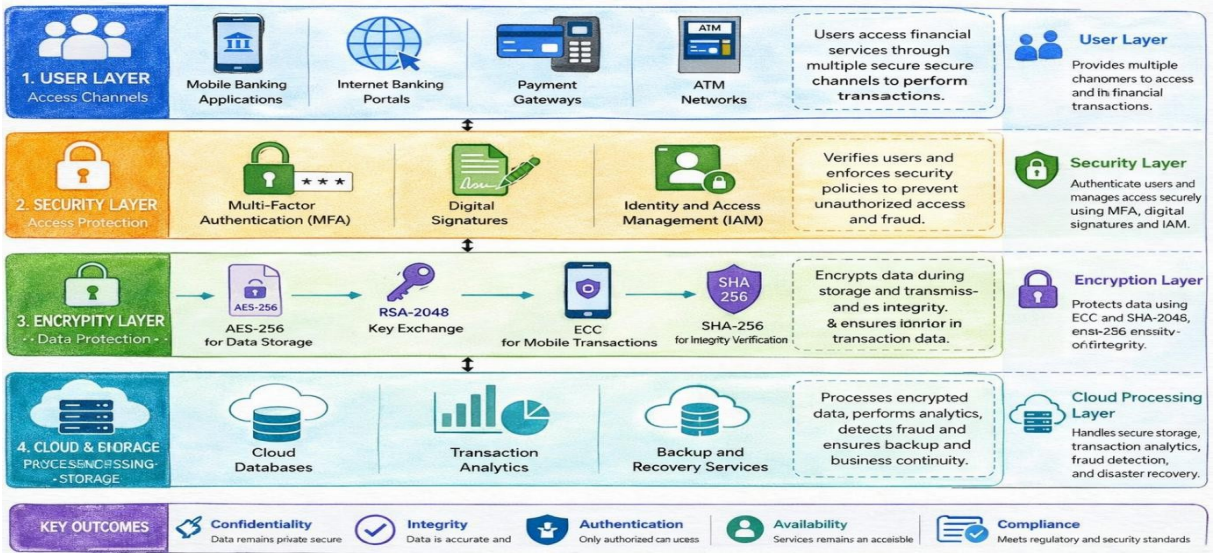


Figure 4.1 Proposed secured Cloud architecture for financial transactions

The **Encryption Layer** provides data protection during storage and transmission. Advanced Encryption Standard (AES-256) is employed to secure sensitive financial data stored in cloud databases, while RSA- 2048 and Elliptic Curve Cryptography (ECC) are used for secure key exchange and communication. Additionally, the Secure Hash Algorithm (SHA-256) is utilized to verify data integrity and detect any unauthorized modifications to transaction records.

The **Cloud Processing Layer** forms the core of the system and manages transaction processing, analytics, and storage functions. This layer consists of cloud databases, transaction analytics engines, fraud detection systems, and backup and recovery services. It securely processes encrypted transaction data, performs real-time fraud analysis, maintains financial records, and ensures business continuity through reliable backup and disaster recovery mechanisms.

Together, these four layers create a robust and scalable cloud-based financial transaction framework that enhances security, improves operational efficiency, and ensures compliance with modern financial regulations.

5 Data Flow Model

The financial transaction process begins when a customer initiates a transaction through a banking application, internet banking portal, mobile wallet, or payment gateway. Before processing the transaction, the system verifies the user's identity using Multi-Factor Authentication (MFA), which may include passwords, One-Time Passwords (OTP), biometric verification, or security tokens to ensure that only authorized users can access the service

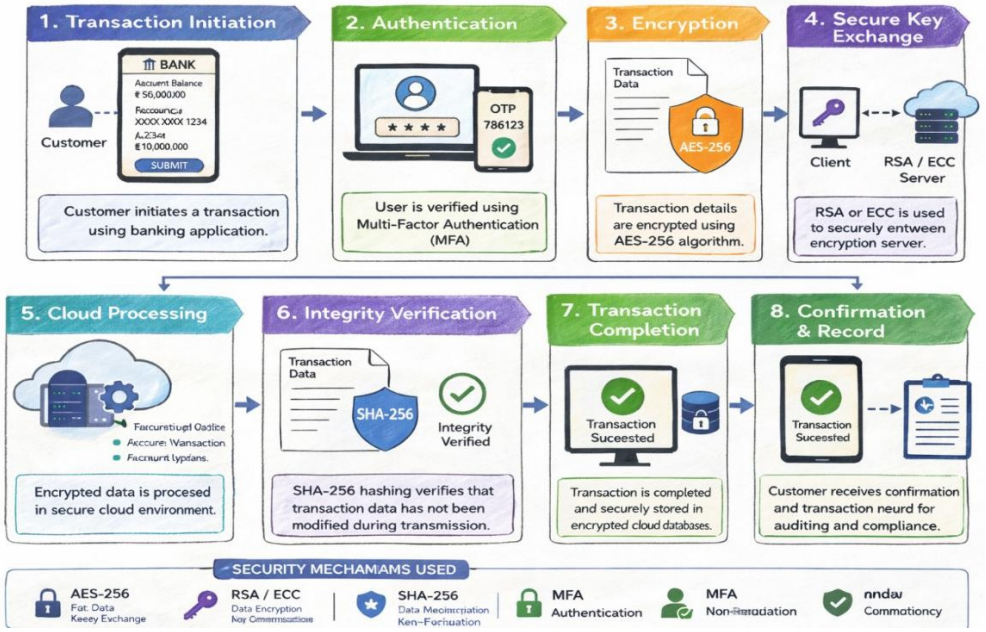


Figure 5.1 Data flow model for Financial Transaction

Once authentication is successfully completed, the transaction details, including account information and payment data, are encrypted using the Advanced Encryption Standard (AES-256) algorithm. This encryption ensures that sensitive financial information remains confidential and protected from unauthorized access during transmission and storage.

To facilitate secure communication between the client device and cloud servers, a secure key exchange mechanism is established using RSA or Elliptic Curve Cryptography (ECC). These asymmetric encryption algorithms securely exchange encryption keys without exposing them to potential attackers, thereby enhancing the overall security of the communication channel.

After encryption and key exchange, the encrypted transaction data is transmitted to the cloud infrastructure for processing. Within the secure cloud environment, transaction validation, payment authorization, fraud detection, and account updates are performed while maintaining data confidentiality.

To ensure data integrity, a Secure Hash Algorithm (SHA-256) hash value is generated and verified during processing. This mechanism detects any unauthorized modification of transaction data and guarantees that the information remains unchanged throughout the transaction lifecycle.

Finally, once the transaction has been successfully verified and processed, the results are securely stored in encrypted cloud databases. The customer receives a confirmation notification, and the transaction record is maintained for future auditing, compliance, and financial reporting purposes. This secure workflow ensures confidentiality, integrity, authentication, and availability of financial data within cloud- based transaction systems.

6. Encryption Algorithms Comparison

Algorithm	Key Size	Security Level	Speed	Application
AES	128 / 192 / 256-bit	Very High	Fast	Data Encryption
RSA	1024 / 2048 / 4096-bit	High	Moderate	Key Exchange
ECC	256 / 384 / 521-bit	Very High	Fast	Mobile Banking
SHA-256	256-bit Hash	High	Fast	Integrity Verification

Various encryption algorithms are used in cloud-based financial systems to provide different security functions, including data protection, secure communication, authentication, and integrity verification. The Advanced Encryption Standard (AES) supports key sizes of 128, 192, and 256 bits and is widely recognized for its very high level of security and fast processing speed. Due to its efficiency in encrypting large volumes of data, AES is commonly used for securing financial transaction data stored in cloud environments.

The Rivest–Shamir–Adleman (RSA) algorithm utilizes key sizes ranging from 1024 to 4096 bits and provides a high level of security. Although RSA requires more computational resources and operates at a moderate speed compared to symmetric encryption algorithms, it is extensively used for secure key exchange, digital signatures, and authentication in financial systems.

Elliptic Curve Cryptography (ECC) employs smaller key sizes, typically 256, 384, and 521 bits, while delivering a security level comparable to RSA. ECC offers faster performance and lower computational overhead, making it particularly suitable for mobile banking applications and resource-constrained devices where efficiency and security are equally important.

The Secure Hash Algorithm (SHA-256) is a cryptographic hashing function that generates a 256-bit hash value to verify data integrity. Unlike encryption algorithms, SHA-256 does not encrypt data but ensures that transaction records remain unchanged during transmission and storage. Its high security and fast execution make it an essential component of secure financial transaction systems.

Overall, AES is best suited for data encryption, RSA is effective for secure key exchange and authentication, ECC provides efficient security for mobile and cloud applications, and SHA-256 ensures the integrity of financial transaction data. Together, these algorithms form a comprehensive security framework for cloud-based financial transactions.

7.Impact of Encryption on Financial Transactions Positive Impacts

Encryption plays a crucial role in securing financial transactions conducted through cloud-based platforms. One of its primary benefits is **data confidentiality**, as encryption ensures that sensitive transaction information can only be accessed by authorized users and systems. This protection significantly reduces the risk of unauthorized access and data breaches.

Another important advantage is **fraud prevention**. By utilizing encrypted communication channels and digital signatures, financial institutions can protect transaction data from tampering and impersonation attacks, thereby reducing the likelihood of fraudulent activities.

Encryption also enhances **customer trust** in digital banking and online payment systems. When customers are confident that their personal and financial information is securely protected, they are more likely to adopt and continue using digital financial services.

Furthermore, encryption supports **regulatory compliance** by helping financial institutions meet the requirements of international security standards and regulations such as PCI-DSS, GDPR, and banking cybersecurity guidelines. Compliance not only protects customer data but also helps organizations avoid legal penalties and reputational damage.

Additionally, strong encryption mechanisms facilitate **secure cloud adoption** by enabling organizations to migrate financial applications, databases, and transaction processing systems to cloud environments while maintaining high levels of security and privacy.

Challenges

Despite its numerous benefits, encryption also presents several challenges. One significant challenge is **computational overhead**, as advanced encryption algorithms require additional processing power and system resources, which may affect transaction speed and overall system performance.

Another challenge is **key management complexity**. The secure generation, distribution, storage, rotation, and recovery of cryptographic keys are critical to maintaining system security. Poor key management practices can compromise even the strongest encryption algorithms.

Finally, the **cost of implementation** can be a concern for financial institutions. Deploying advanced encryption technologies, security infrastructure, and compliance frameworks often requires substantial investment in hardware, software, and skilled cybersecurity professionals. Although these costs can be significant, they are generally justified by the enhanced security and protection provided to financial systems and customer data.

8.Experimental Analysis

To evaluate the effectiveness of various encryption algorithms in securing cloud-based financial transactions, a simulation environment was developed and tested using commonly adopted cryptographic techniques. The analysis focused on measuring encryption time, decryption time, and overall security performance for protecting financial transaction data.

The experimental results indicate that the **AES-256** algorithm achieved the fastest performance, requiring only **18 milliseconds for encryption** and **15 milliseconds for decryption**. Due to its high processing speed and strong security features, AES-256 is highly suitable for encrypting large volumes of financial transaction data stored or processed in cloud environments.

The **RSA-2048** algorithm demonstrated the highest computational overhead, with an encryption time of **120 milliseconds** and a decryption time of **95 milliseconds**. Although RSA requires more processing resources, it provides strong security and is widely used for secure key exchange and digital signature generation in financial systems.

The **ECC-256** algorithm showed a balanced performance, requiring **35 milliseconds for encryption** and **30 milliseconds for decryption**. ECC offers a high level of security comparable to RSA while utilizing smaller key sizes, making it particularly efficient for mobile banking and resource-constrained devices.

Encryption Algorithm	Encryption Time (ms)	Decryption Time (ms)	Security Rating
AES-256	18	15	Excellent
RSA-2048	120	95	Very High
ECC-256	35	30	Excellent

Table 8.1 Performance Comparison of Encryption Algorithms

The experimental findings reveal that AES-256 provides superior performance for bulk financial data encryption due to its low processing time and high efficiency. In contrast, RSA-2048 and ECC-256 are more suitable for secure key management, authentication, and digital signature applications. Based on these observations, a **hybrid encryption model combining AES, RSA, and ECC** offers the most effective solution by leveraging the speed of AES for data encryption and the strong security capabilities of RSA and ECC for key exchange and authentication. This integrated approach ensures an optimal balance between security, performance, and scalability for cloud-based financial transaction systems.

9.Future Scope

The future of cloud-based financial transaction systems will be driven by emerging technologies that offer enhanced security, privacy, and resilience against evolving cyber threats. As cyberattacks become increasingly sophisticated, traditional security mechanisms may no longer be sufficient to protect sensitive financial data. Therefore, future financial cloud systems are expected to integrate advanced security technologies to strengthen overall system protection.

One promising area of development is **Post-Quantum Cryptography (PQC)**, which is designed to resist attacks from quantum computers. As quantum computing advances, existing encryption algorithms such as RSA and ECC may become vulnerable; therefore, quantum-resistant cryptographic techniques will play a critical role in securing future financial transactions.

Another significant advancement is **AI-Based Threat Detection**, where artificial intelligence and machine learning algorithms continuously monitor transaction activities, identify suspicious behavior, and detect potential cyberattacks in real time. These intelligent systems can significantly improve fraud detection and incident response capabilities.

Blockchain-enabled transaction security is also expected to gain wider adoption in financial ecosystems. Blockchain technology provides transparency, immutability, and decentralized verification mechanisms, making financial transactions more secure and resistant to tampering or fraud.

Future systems may further benefit from **Homomorphic Encryption**, which enables computations to be performed directly on encrypted data without requiring decryption. This capability enhances data privacy while allowing secure processing and analysis of sensitive financial information within cloud environments.

The implementation of a **Zero Trust Security Architecture** will further strengthen cloud security by continuously verifying users, devices, and applications before granting access to resources. This approach minimizes the risk of unauthorized access and insider threats by eliminating implicit trust within the network.

Additionally, **Secure Multi-Party Computation (SMPC)** will allow multiple organizations or financial institutions to collaboratively process and analyze data while preserving the confidentiality

of their individual datasets. This technology is particularly valuable for secure financial analytics and inter- organizational collaborations.

Overall, the integration of these advanced technologies will significantly enhance the security, privacy, scalability, and trustworthiness of cloud-based financial ecosystems. As a result, future financial systems will be better equipped to address emerging cybersecurity challenges while supporting secure and efficient digital financial services.

10. Conclusion

Cloud computing has become a fundamental component of modern financial services. However, ensuring financial transactions remains a critical challenge. Encryption algorithms such as AES, RSA, and ECC provide robust mechanisms for protecting sensitive financial information stored and processed in cloud environments. The proposed framework demonstrates how layered security and hybrid encryption strategies can significantly improve confidentiality, integrity, and authentication while maintaining transaction efficiency. Future research should focus on integrating artificial intelligence and post-quantum cryptographic techniques to address emerging cybersecurity threats in cloud-based financial systems.

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