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Secure and Verifiable Customer Data Transfers Using Multi-Layer Encryption and Blockchain Anchoring to Support Fraud and Anomaly Detection

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Abstract

The secure transfer of customer data is a critical requirement in contemporary digital ecosystems, particularly in sectors such as banking, healthcare, cloud computing, and e-commerce, where sensitive information is routinely exchanged across distributed and heterogeneous environments. Although encryption is widely employed to protect data in transit, real-world data transfer workflows often involve multiple intermediaries, storage points, and administrative domains, increasing the risk of unauthorized access, data tampering, and post-transfer integrity disputes. Existing security mechanisms primarily emphasize confidentiality during transmission but provide limited support for verifiable integrity, non-repudiation, and auditability after data transfer completion.

This paper proposes a practical framework for securing customer data transfers by integrating multi-layer encryption with blockchain-based anchoring. The framework employs layered cryptographic protection to safeguard data confidentiality and authenticity at different stages of the transfer process, while cryptographic hashes of the transferred data are anchored on a permissioned blockchain to establish immutable and tamper-evident proof of data integrity and transfer occurrence. By anchoring only cryptographic representations rather than raw data, the proposed approach preserves privacy, minimizes performance overhead, and avoids the scalability limitations associated with on-chain data storage. The framework is designed for seamless integration with existing infrastructures and emphasizes regulatory compliance, operational feasibility, and scalability. Through architectural analysis and security evaluation, the paper demonstrates how the combined use of multi-layer encryption and blockchain anchoring can enhance trust, accountability, and resilience in customer data transfer processes.

Index Terms : Customer data security, secure data transfer, multi-layer encryption, blockchain anchoring, data integrity, privacy preservation, distributed ledger technology, auditability

I. Introduction

The protection of customer data during transmission has become a central concern for modern digital services, as organizations increasingly depend on distributed architectures, cloud platforms, and third-party integrations to exchange sensitive information. Customer data—including personal identifiers, financial details, health records, and transactional metadata—frequently traverses untrusted networks and crosses organizational boundaries. Any compromise during transfer can lead to severe consequences, including financial loss, regulatory penalties, reputational damage,

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and erosion of customer trust. Consequently, ensuring secure and verifiable data transfer has emerged as a fundamental requirement for digital infrastructure design.

Traditional approaches to securing data in transit rely heavily on cryptographic protocols that provide confidentiality and, in some cases, authentication between communicating parties. Transport-layer security mechanisms and application-level encryption have proven effective against passive eavesdropping and basic man-in-the-middle attacks. However, these mechanisms primarily focus on protecting data during transmission and offer limited guarantees once the data has been delivered. In practical deployments, data is often relayed through intermediaries, temporarily stored, or processed asynchronously, making it difficult to conclusively verify that the data received is identical to the data originally sent or to resolve disputes related to unauthorized modification after transfer.

To enhance security, multi-layer encryption techniques have been proposed, wherein cryptographic protection is applied at multiple levels of the communication stack. By encrypting data both at the application layer and the transport layer, such approaches improve resilience against partial compromise and reduce reliance on a single security mechanism. While multi-layer encryption strengthens confidentiality and authenticity, it does not inherently provide an external or independently verifiable record of data integrity across the entire transfer lifecycle. As a result, organizations still face challenges in establishing accountability and auditability for data exchanges, particularly in regulated environments.

In parallel, blockchain and distributed ledger technologies have attracted significant attention for their ability to provide immutable, tamper-evident records without centralized control. These properties make blockchains appealing for applications requiring strong integrity guarantees and transparent audit trails. Several studies have explored blockchain-based approaches for data security and integrity assurance; however, many such solutions attempt to store or exchange actual data on the ledger. This design choice introduces serious concerns related to scalability, privacy, performance overhead, and regulatory compliance, limiting the practicality of direct blockchain-based data transfer solutions.

Despite advances in both cryptographic protection and decentralized trust mechanisms, a gap remains between secure data transmission and verifiable post-transfer assurance. Existing solutions often address confidentiality, integrity, and auditability in isolation rather than as a unified process. In complex data exchange scenarios, particularly those involving customer data, organizations require a solution that not only protects data during transfer but also provides immutable proof that the data was transmitted correctly and without alteration, without exposing sensitive content or disrupting operational workflows.

This paper addresses this gap by proposing a practical framework that integrates multi-layer encryption with blockchain anchoring for securing customer data transfers. The framework applies layered encryption techniques to ensure confidentiality and authenticity throughout the transmission process, while cryptographic hashes of transferred data are anchored to a permissioned blockchain to provide tamper-evident and independently verifiable integrity guarantees. By decoupling data transfer from blockchain storage, the proposed approach avoids scalability and privacy limitations while enabling strong auditability. The framework is designed

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for incremental deployment within existing systems and aligns with regulatory and operational requirements.

The remainder of this paper is organized as follows. Section II reviews related work on secure data transfer, encryption techniques, and blockchain-based integrity mechanisms. Section III presents the system model and problem formulation. Section IV describes the proposed framework and methodology. Section V discusses the novelty and research contributions. Section VI provides evaluation and analysis, and Section VII concludes the paper with directions for future work.

II. Related Work

Secure data transfer has been extensively studied in the context of network security and applied cryptography, with early work focusing on encryption protocols that provide confidentiality and authentication over untrusted networks. Transport-layer security mechanisms, particularly TLS, have become the de facto standard for securing data in transit and are widely deployed across web services and cloud platforms [1], [3], [5], [23]. While these protocols effectively protect against passive eavesdropping and many active attacks, prior studies note that they primarily secure communication channels and provide limited guarantees regarding post-transfer data integrity and non-repudiation once data leaves the secure session context [4], [7].

To enhance confidentiality and resilience, researchers have proposed multi-layer encryption approaches that apply cryptographic protection at multiple levels of the communication stack. Such approaches typically combine application-layer encryption with transport-layer security, ensuring that data remains protected even if one security layer is compromised [1], [4], [6]. Multi-layer encryption is particularly relevant in distributed and cloud-based environments where data may traverse intermediaries, be cached temporarily, or be processed asynchronously. However, existing multi-layer encryption techniques focus predominantly on confidentiality and authentication and do not inherently provide externally verifiable evidence that the transferred data has not been altered after delivery [7], [29].

Beyond encryption, cryptographic primitives such as secure hashing, digital signatures, and authenticated data structures have been widely studied to support integrity verification and non-repudiation [2], [7], [30]. Time-stamping and hash-based commitment schemes enable proof of data existence and integrity at a given point in time and form the foundation of many integrity assurance systems [8], [10]. While these techniques provide strong cryptographic guarantees, they are typically implemented in centralized systems, which limits their usefulness in multi-party or cross-organizational settings where trust cannot be assumed in a single authority [9].

Blockchain and distributed ledger technologies introduced decentralized mechanisms for maintaining immutable and tamper-evident records through distributed consensus. Foundational work demonstrated how blockchains could serve as append-only ledgers resistant to modification without centralized control [11], [12]. Subsequent research explored blockchain-based approaches for data integrity, provenance, and accountability across distributed environments [18], [22]. Some proposed systems store encrypted data directly on-chain to leverage immutability, but such designs

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face significant scalability, privacy, and regulatory challenges, particularly when handling sensitive customer data [16], [20].

To address these challenges, blockchain anchoring techniques have emerged as a practical alternative, wherein cryptographic hashes of data are recorded on a blockchain rather than the data itself. Anchoring enables proof of existence and integrity verification without exposing sensitive content or incurring excessive storage overhead [15], [18]. These approaches have been applied to document verification, data provenance, and integrity assurance systems, demonstrating improved scalability and privacy preservation compared to full on-chain data storage [17], [21]. Nevertheless, most anchoring-based solutions are studied independently of secure data transfer mechanisms and do not explicitly integrate with layered encryption strategies used during transmission.

Recent studies have attempted to combine blockchain technologies with secure data exchange and cloud-based systems, highlighting the potential for decentralized trust in cross-organizational environments [19], [27]. However, many such approaches introduce tight coupling between blockchain operations and data transfer workflows, leading to increased system complexity and performance overhead. Additionally, solutions relying on public or permissionless blockchains may not align with regulatory and compliance requirements for handling customer data, such as those mandated by NIST and ISO standards or data protection regulations like GDPR [23]–[26].

In contrast to prior work, this paper focuses on a decoupled and practical integration of multi-layer encryption and blockchain anchoring for securing customer data transfers. Rather than treating blockchain as a transport or storage medium, the proposed framework leverages it solely as an immutable integrity anchor. By combining layered cryptographic protection during transmission with post-transfer anchoring of cryptographic hashes, the framework provides end-to-end confidentiality, integrity, and auditability while preserving scalability and privacy. This integrated approach directly addresses limitations identified in existing encryption-centric and blockchain-centric solutions and aligns with regulatory and operational requirements for real-world deployment [24]–[26].

III. System Model and Problem Formulation

Modern digital systems increasingly rely on the transfer of customer data across distributed infrastructures, cloud services, and interconnected platforms. In the considered system model, a data sender is responsible for transmitting sensitive customer data to an intended data receiver over potentially untrusted networks. The sender and receiver may belong to different administrative domains, and the communication path may involve intermediary services, network gateways, or storage components. This environment reflects realistic deployment scenarios in which customer data is exchanged across heterogeneous and loosely coupled systems.

Customer data is assumed to include digital information whose confidentiality and integrity are critical, such as personal identifiers, transactional records, or application-specific payloads. During transmission, this data is exposed to various risks, including interception, unauthorized

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modification, replay, and substitution attacks. While conventional secure communication mechanisms provide protection against many network-level threats, they do not inherently guarantee that the data received is identical to the data originally transmitted once the transfer process has completed, particularly in asynchronous or multi-hop environments.

In the baseline system, data protection is typically achieved through encryption mechanisms applied during transmission. However, once data is delivered and decrypted at the receiver, traditional security mechanisms offer limited support for proving that the data has not been altered during or after transfer. This limitation becomes significant in scenarios involving dispute resolution, compliance verification, or forensic analysis, where independent and verifiable evidence of data integrity is required. The absence of such evidence creates a trust gap between communicating parties, especially when data traverses organizational boundaries.

The problem addressed in this paper is the lack of a practical and verifiable mechanism to ensure end-to-end integrity of customer data transfers beyond the transmission phase. Specifically, the challenge lies in designing a framework that not only protects data confidentiality during transfer but also provides tamper-evident proof that the transferred data has remained unaltered throughout its lifecycle. Any proposed solution must avoid exposing sensitive data, must not impose excessive performance overhead, and must be compatible with existing data transfer infrastructures.

The system model further assumes the availability of a shared but controlled external component that can be used to record integrity evidence without participating directly in data transfer. This component is not trusted with raw customer data and does not interfere with communication workflows. Instead, it serves as an independent reference point for verifying the integrity and occurrence of data transfers. Leveraging such a component enables separation of data confidentiality concerns from integrity verification requirements.

Under this model, the core objective is to establish a secure data transfer framework that combines strong cryptographic protection during transmission with independently verifiable integrity assurance after transfer completion. Addressing this objective forms the basis for the proposed framework described in the following section, which integrates multi-layer encryption with blockchain anchoring in a decoupled and practical manner.

IV. Proposed Framework and Methodology

The proposed framework is designed to secure customer data transfers by integrating multi-layer encryption with blockchain-based integrity anchoring. The methodology focuses on providing strong confidentiality during data transmission while enabling verifiable and tamper-evident integrity assurance after transfer completion. A key design principle is the separation of data protection mechanisms from integrity verification mechanisms, ensuring that security enhancements do not disrupt existing data transfer workflows or introduce unnecessary performance overhead.

At a high level, the framework consists of three logical components: a data sender, a data receiver, and an external integrity anchoring layer. The data sender and receiver perform encrypted data exchange using layered cryptographic controls, while the anchoring layer records cryptographic

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representations of transferred data without participating in data transmission or storage. This separation allows the framework to strengthen trust and accountability without exposing sensitive customer data or relying on centralized integrity management.

A. Multi-Layer Encryption Strategy

The first layer of protection in the proposed framework is a multi-layer encryption strategy applied prior to and during data transmission. Before transmission, customer data is encrypted at the application layer using a symmetric encryption scheme. This ensures that data remains confidential regardless of the underlying transport mechanism or intermediary systems involved in the transfer. Application-layer encryption also enables data to remain protected in scenarios where data may be temporarily stored or processed during transfer.

In addition to application-layer encryption, transport-layer security is employed to protect the communication channel between the sender and receiver. This second layer of encryption safeguards against network-level attacks such as packet inspection, traffic interception, and session hijacking. By combining encryption at multiple layers, the framework reduces dependence on a single security control and improves resilience against partial system compromise.

The use of layered encryption ensures that even if one layer is misconfigured or compromised, the remaining layers continue to provide confidentiality and authenticity guarantees. This approach is particularly valuable in distributed and cloud-based environments, where data may traverse heterogeneous infrastructure components beyond the direct control of the communicating parties.

B. Data Transfer and Hash Generation Process

Once customer data is encrypted using the multi-layer encryption strategy, it is transmitted from the sender to the receiver through standard communication channels. Upon completion of the data transfer, both parties independently compute a cryptographic hash of the original plaintext data prior to encryption. This hash serves as a compact and deterministic representation of the data content and forms the basis for subsequent integrity verification.

The hash generation process is designed to be lightweight and deterministic, ensuring that identical data produces identical hash outputs while even minor data modifications result in significantly different hash values. Importantly, the hash is computed over the data itself rather than over encrypted payloads, enabling integrity verification that is independent of encryption parameters or session-specific artifacts.

By decoupling hash generation from encryption, the framework allows encryption schemes to evolve without affecting integrity verification mechanisms. This design choice enhances long-term flexibility and compatibility with cryptographic upgrades.

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C. Blockchain Anchoring Mechanism

To establish immutable and independently verifiable proof of data integrity, the computed data hash is anchored to a permissioned blockchain. The blockchain functions solely as an integrity reference layer and does not store customer data or encrypted payloads. Instead, it records the hash value along with minimal metadata such as a timestamp or transfer identifier.

Anchoring the hash on a blockchain ensures that once the integrity reference is recorded, it cannot be altered without detection. Because only cryptographic representations are stored, the anchoring process preserves data confidentiality and avoids the scalability limitations associated with storing large data objects on-chain. The permissioned nature of the blockchain allows controlled participation and governance, making the framework suitable for enterprise and regulated environments.

The anchoring operation is performed asynchronously after data transfer completion, ensuring that blockchain interactions do not introduce latency into the data transmission path. This design choice maintains high data transfer performance while still providing strong post-transfer integrity guarantees.

D. Integrity Verification Workflow

Integrity verification can be performed at any point after data transfer by recomputing the cryptographic hash of the received data and comparing it with the hash anchored on the blockchain. A match between the two values confirms that the data has not been altered since the time of anchoring. Any discrepancy indicates unauthorized modification, corruption, or substitution of data.

This verification process does not require access to the original encryption keys or transfer session details, enabling independent verification by authorized parties if required. As a result, the framework supports dispute resolution, compliance validation, and forensic analysis without exposing sensitive customer data or relying on trust in a single system component.

Because integrity verification relies on deterministic cryptographic comparison, it can be automated and integrated into existing audit or monitoring workflows, further enhancing operational efficiency.

E. Performance and Deployment Considerations

The proposed framework is designed for practical deployment within existing data transfer infrastructures. By limiting blockchain interactions to compact hash anchoring operations and

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performing these operations asynchronously, the framework minimizes performance overhead and avoids disrupting high-throughput data exchange processes.

Scalability is supported through the use of lightweight integrity records and controlled blockchain participation. Since the volume of data anchored on the blockchain grows linearly with the number of transfers rather than with data size, the framework remains feasible even in large-scale systems handling frequent data exchanges. Furthermore, because encryption and data transfer mechanisms remain unchanged, the framework can be adopted incrementally without requiring architectural redesign.

F. Methodological Significance

The methodological significance of the proposed framework lies in its balanced integration of cryptographic protection and decentralized integrity assurance. By combining multi-layer encryption with blockchain anchoring in a decoupled manner, the framework addresses confidentiality, integrity, and auditability as a unified process. This approach demonstrates how selective use of blockchain technology can enhance trust in customer data transfers without introducing unnecessary complexity or compromising privacy.

V. Novelty and Research Contributions

A. Integrated Yet Decoupled Security Architecture

The central novelty of this work lies in the architectural integration of multi-layer encryption and blockchain anchoring while maintaining a strict separation of concerns between confidentiality protection and integrity verification. Existing approaches to secure data transfer typically emphasize encryption as the primary defense mechanism, whereas blockchain-based solutions often attempt to extend security guarantees by embedding data storage or transmission directly within distributed ledgers. Both approaches, when applied in isolation or in a tightly coupled manner, face limitations related to scalability, privacy exposure, or operational complexity.

This work advances the state of the art by explicitly decoupling these responsibilities. Multi-layer encryption is employed solely to protect customer data confidentiality and authenticity during transmission, leveraging well-established cryptographic practices without modification. Blockchain technology, in contrast, is used only as an external integrity anchoring mechanism that records cryptographic representations of transferred data rather than the data itself. By limiting the role of the blockchain to integrity anchoring, the framework avoids common pitfalls such as excessive on-chain storage, dependency on blockchain availability during data transfer, and leakage of sensitive information.

This architectural separation is not merely an implementation detail but a deliberate design decision that enables the framework to remain flexible, scalable, and compatible with existing

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systems. It allows encryption mechanisms and blockchain platforms to evolve independently, ensuring long-term adaptability. As a result, the proposed framework demonstrates that blockchain can be applied selectively and purposefully to complement, rather than replace, conventional security mechanisms in data transfer systems.

B. Persistent Integrity Assurance Across the Data Transfer Lifecycle

A second major contribution of this work is the introduction of persistent integrity assurance that extends beyond the active data transfer phase. Conventional secure communication mechanisms are primarily designed to protect data while it is in transit and provide limited support for verifying integrity once the transfer session has concluded. In practical deployments, however, data often undergoes subsequent storage, processing, or redistribution, during which integrity violations may occur without reliable means of detection.

The proposed framework addresses this limitation by anchoring cryptographic hashes of transferred data on a tamper-evident blockchain after transmission. This anchoring establishes a permanent and immutable integrity reference that can be used to verify data authenticity at any point in time, independent of the original transfer context. Unlike transient session-based guarantees, this approach enables post-transfer validation, long-term auditing, and dispute resolution without reliance on centralized logs or trusted intermediaries.

Importantly, the framework achieves this persistent assurance without compromising data confidentiality. Since only cryptographic hashes are anchored, no sensitive customer information is disclosed, and verification can be performed without access to encryption keys or session metadata. This capability is particularly valuable in multi-party and cross-organizational environments, where data consumers, auditors, or third parties may require integrity verification without being granted access to the underlying data. By bridging the gap between secure transmission and long-term verifiability, the proposed framework addresses a critical and underexplored aspect of secure data exchange.

C. Practical Deployability and System-Level Impact

The third key contribution of this work is its emphasis on practical deployability and system-level impact. Many blockchain-based security proposals introduce substantial architectural changes or impose performance overheads that hinder adoption in real-world systems. In contrast, the proposed framework is designed to integrate seamlessly with existing data transfer infrastructures, requiring minimal changes to established workflows.

Because blockchain interactions are limited to compact hash anchoring operations performed asynchronously, the framework avoids introducing latency into the data transfer path. The volume of data recorded on the blockchain scales with the number of transfers rather than with data size,

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ensuring predictable growth and manageable overhead. This makes the framework suitable for high-throughput environments where customer data is exchanged frequently and at scale.

Furthermore, the framework supports incremental adoption. Organizations can deploy multi-layer encryption independently of blockchain anchoring and later integrate integrity anchoring as an additional assurance layer. This flexibility reduces deployment risk and allows system operators to balance security, performance, and operational constraints. By demonstrating how advanced cryptographic protection and decentralized integrity assurance can be combined without disrupting existing systems, this work provides a realistic and actionable blueprint for improving customer data transfer security in practice.

VI. Evaluation and Analysis

The proposed framework is evaluated with respect to security effectiveness, performance overhead, and scalability under realistic data transfer scenarios. Since the framework is designed as an enhancement layer rather than a replacement for existing data transfer mechanisms, the evaluation focuses on incremental costs and security benefits introduced by multi-layer encryption and blockchain anchoring. The analysis is qualitative and analytical in nature, which is consistent with early-stage system design and security architecture research.

A. Security Effectiveness and Threat Coverage

From a security standpoint, the framework provides protection against a broad range of threats affecting customer data transfers. Multi-layer encryption ensures confidentiality and authenticity during transmission, protecting data from interception, replay, and unauthorized modification at the network level. Even if one encryption layer is compromised due to misconfiguration or partial system exposure, the remaining layers continue to protect data confidentiality, thereby increasing overall system resilience.

The blockchain anchoring mechanism strengthens integrity assurance by enabling tamper-evident verification after data transfer completion. Any unauthorized modification of transferred data—whether during transit, at intermediate storage points, or after delivery—results in a mismatch between the recomputed data hash and the hash anchored on the blockchain. This property allows integrity violations to be detected deterministically, even long after the original transfer has occurred. Unlike centralized logging approaches, the integrity reference cannot be altered without detection, eliminating reliance on a single trusted authority.

Additionally, the framework supports non-repudiation of data transfers. By anchoring integrity evidence externally, disputes regarding whether specific data was transmitted or altered can be resolved independently of the sender or receiver. This capability is particularly valuable in cross-organizational environments where trust relationships are limited and post-transfer accountability is required.

B. Performance Overhead and Operational Impact

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The performance impact of the proposed framework is intentionally minimized through architectural design choices. Data encryption and decryption operations are performed using standard cryptographic primitives that are already widely deployed in secure communication systems. As a result, the computational overhead introduced by multi-layer encryption is comparable to existing secure data transfer solutions and does not introduce additional cryptographic complexity beyond established practices.

Blockchain interactions are limited to anchoring compact cryptographic hashes rather than full data payloads. These anchoring operations are executed asynchronously after data transfer completion, ensuring that blockchain latency does not affect end-to-end data transfer performance. Consequently, the perceived transfer time from the perspective of the sender and receiver remains governed by network conditions and encryption overhead rather than distributed ledger consensus.

Because the size of anchored records is fixed and independent of data size, the framework avoids bandwidth and storage overheads commonly associated with blockchain-based data storage solutions. This makes the approach suitable for large data transfers and frequent data exchange scenarios, where storing data or encrypted payloads on-chain would be impractical.

C. Scalability and Deployment Feasibility

Scalability is a key consideration for systems handling customer data at scale. In the proposed framework, scalability is primarily influenced by the rate of data transfers rather than the volume of data. Since each transfer results in a single integrity anchor, ledger growth is linear with respect to the number of transfers and remains predictable over time. This property allows system operators to plan storage and maintenance requirements more effectively.

The use of a permissioned blockchain further enhances deployment feasibility by allowing controlled participation and governance. Organizations can define who is allowed to anchor and verify integrity records, aligning the framework with operational and regulatory requirements. Moreover, because the framework does not require modification of existing data transfer protocols, it can be deployed incrementally and selectively within an organization’s infrastructure.

Overall, the evaluation indicates that the proposed framework provides meaningful security benefits with minimal operational disruption. By balancing strong cryptographic protection with lightweight decentralized integrity anchoring, the framework achieves a practical trade-off between security, performance, and scalability, making it suitable for real-world customer data transfer scenarios.

VII. Conclusion and Future Work

This paper presented a practical framework for securing customer data transfers by integrating multi-layer encryption with blockchain-based integrity anchoring. By combining strong cryptographic protection during data transmission with an external and immutable integrity reference, the proposed approach addresses key limitations of existing secure data transfer mechanisms. The framework ensures data confidentiality, enables tamper-evident integrity

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verification beyond the transfer phase, and supports independent validation without exposing sensitive customer information.

A central contribution of this work is the deliberate decoupling of encryption and blockchain functionalities. Rather than relying on blockchain as a data transport or storage medium, the framework leverages it selectively as an integrity anchor. This design choice preserves performance, scalability, and privacy while strengthening trust and accountability in distributed data exchange environments. The analysis demonstrates that meaningful integrity guarantees can be achieved without disrupting existing data transfer workflows or introducing excessive operational overhead.

The proposed framework is designed with practical deployment in mind and can be incrementally integrated into existing systems. By limiting blockchain interactions to lightweight hash anchoring operations and maintaining compatibility with standard encryption techniques, the framework offers a realistic path for organizations seeking to enhance data transfer security under regulatory and operational constraints.

Future work will focus on empirical evaluation through prototype implementation and quantitative performance measurement under diverse workloads and network conditions. Additional research directions include extending the framework with advanced privacy-preserving techniques such as zero-knowledge proofs, exploring automated verification workflows for large-scale deployments, and investigating cross-domain interoperability for multi-party data transfer scenarios. These extensions aim to further strengthen the applicability and robustness of the framework in real-world customer data exchange systems.

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