Interchain Claims Protocol: A Proof-of-Concept for Cross-Chain Insurance Claim Synchronization

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***Abstract*—Insurance workflows often span multiple carriers, reinsurers, and regulators on distinct ledgers, yet most blockchain prototypes remain single-chain. This paper presents a lightweight *Interchain Claims Protocol* that mirrors claim events across independent blockchains using a relayer-driven mechanism. This study presents a proof-of-concept that demonstrates correctness, idempotency, and sub-second local latency, providing early validation that cross-chain claim synchronization is feasible for multi-party insurance processes.**

***Index Terms*—Blockchain, Insurance, Cross-chain, Interoperability, Smart Contracts**

I. Introduction

Insurance companies frequently collaborate to settle policyholder claims through mechanisms such as reinsurance, co-insurance, and subrogation [1]. While intra-company claim processing is already complex, inter-company collaboration further increases the challenge. Existing research has introduced blockchain-based solutions that enhance security, immutability, and transparency within individual insurers [1]–[3]. Although blockchain continues to improve transparency and trust in diverse networks and entities [4], disparate blockchain implementations across companies create isolated systems that hinder interoperability. Although blockchain-based claims processing [5] and cross-chain communication protocols [6] exist, no dedicated cross-blockchain framework for inter-company insurance claim processing has been identified, posing a significant barrier to blockchain adoption in the insurance industry.

We introduce the Interchain Claims Protocol (ICP), a minimal but extensible mechanism for mirroring insurance claim updates between independent blockchains. ICP defines a message format, event propagation model, and idempotent smart contracts that ensure replay-safe synchronization. A two-chain proof-of-concept (ICP-PoC) validates its correctness and latency performance.

II. Methodology

This study introduces four interconnected blockchain-based entity systems designed for decentralized insurance operations:

Insurance Chains: Each insurer operates an independent blockchain. When a claim spans multiple insurers, the originating chain issues a structured `ClaimEvent` containing the claim identifier, status, and an auxiliary (`aux`) header specifying target chains for inter-chain communication.

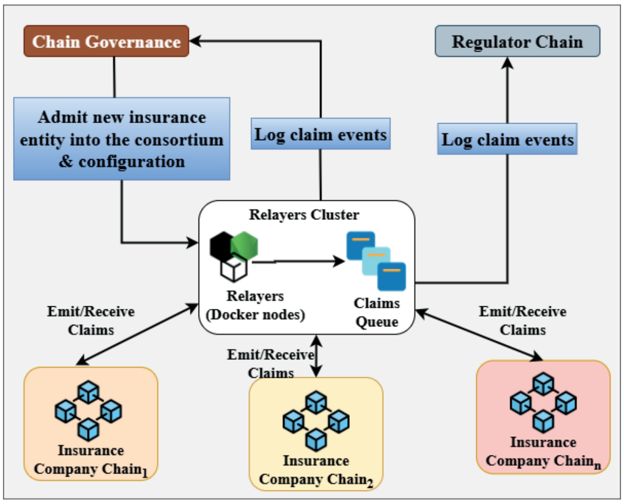

Fig. 1. Interchain Claims System architecture.

Relayer Cluster: A set of containerized relayers (Docker on AWS EKS) continuously monitor all chains and push detected events into a shared message queue. The queue guarantees ordered, fault-tolerant message delivery, enabling relayers to replay unprocessed events after an outage without duplication. The cluster design enhances throughput, resilience, and redundancy compared to a single relayer instance.

Governance Chain: Operated by consortium members (insurance company representatives), this chain maintains consortium metadata, including member credentials, relayer keys, and administrative records. While ideally blockchain-based for transparency and immutability, it may alternatively be implemented as a web application backed by conventional databases.

Regulator Chain: Managed by governmental regulatory agencies, this chain logs all inter-chain claim transactions to ensure transparency, auditability, and regulatory compliance within the insurance ecosystem.

A. Implementation

Claim data flows from the origin chain, where a `ClaimEvent` is emitted, to the destination, governance, and regulator chains. Destination contracts validate nonces and ignore duplicates, ensuring reliability via event replay, queue persistence, and idempotent logic. A minimal PoC with two local Ethereum-compatible networks (*Origin* and *Destination*) was implemented in Hardhat, each running `InterchainClaims.sol` (Solidity 0.8.20). A TypeScript relayer (Viem 2.38) subscribed to the origin via JSON-RPC and invoked `submitClaimEvent()` on the destination. Experiments with `NUM_CLAIMS` = 20–1000 measured end-to-end latency and throughput, computed as in Equation 1.

$$L_{\text{avg}} = \frac{1}{N}\sum_{i=1}^{N}(t_{\text{recv},i} - t_{\text{emit},i}), \quad (1)$$

where N is the total number of claims, $t_{\text{emit},i}$ the emission timestamp, and $t_{\text{recv},i}$ the corresponding receipt timestamp. Microsecond-level timing and deterministic block intervals enabled precise latency profiling, with aggregated results analyzed in Python for comparative evaluation.

III. Performance Evaluation

Table I illustrates that the ICP exhibits stable and predictable performance across varying loads, with average latency ranging from 1508.3ms to 3451.9ms and p95 latency remaining near 4s, indicating consistent tail performance. Latency improved up to 500 claims due to batching efficiency, but increased at 1000 claims, suggesting network saturation. Throughput ranged between 4.74 and 5.14 ev/s, peaking at 500 claims, where latency and throughput were best balanced. The protocol achieved 100% correctness under all conditions, confirming reliable synchronization and consensus.

TABLE I
Model Evaluation

Claims Sent	Average Latency (ms)	p95 Latency (ms)	Throughput (ev/s)	Correctness (%)
20	2228.9	4039	4.94	100
100	1508.3	4031	4.95	100
500	1548.3	3994	5.14	100
1000	3451.9	4388	4.74	100

Similarly, Figure 2 confirms that while the ICP maintains operational integrity under increasing load, latency grows superlinearly with the number of claims, signaling scalability constraints.

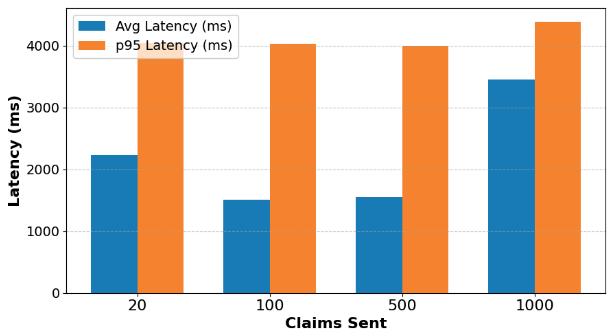

Fig. 2. Cross-Chain Claims Performance vs Load

Overall, ICP sustains high reliability and scalability up to moderate loads (≤500 claims), with latency degradation at higher volumes indicating the need for further optimization in interchain communication and validator scalability. Throughput eventually stabilizes, signaling scalability constraints. These findings highlight the need for future optimization of cross-chain message batching, asynchronous verification, or relay parallelization to enhance the system's performance and scalability for real-world, high-volume insurance claim synchronization scenarios.

IV. Conclusion

ICP-PoC demonstrates a practical foundation for synchronizing insurance claim states between independent blockchains. Its lightweight, replay-safe design achieves low latency and full correctness in local tests, paving the way for interoperable insurance ecosystems spanning multiple carriers, reinsurers, and regulators. In production, SQS would be replaced or supplemented by a verifiable message bus such as Kafka-on-EKS or a decentralized pub/sub fabric, providing higher throughput and region-level fault tolerance. Further work includes cryptographic proofs of relay authenticity, on-chain governance of relayer keys, encrypted payloads for privacy, and regulator-chain analytics for audit and compliance visibility. A fuller implementation of the system using different blockchain technologies, a relayer cluster, governance, and regulator chains will further test the reliability of the protocol.

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