Demo: Streamlining Health Insurance Claims Verifications with AI-Blockchain Integration through AI+ROAX (Rod of Asclepius eXchange)

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Abstract

Current healthcare systems are inefficient and require technological overhaul. The administrative burden of health insurance claims inundates physicians with paperwork and creates friction between providers, patients, and insurers. The claims process is further complicated by the lack of interoperability between electronic medical record systems and the need for verifiable and trusted documentation in a trustless environment. We present AI+ROAX, a demonstration of a novel health informatics platform that integrates a generative AI agent with ROAX (Rod of Asclepius Exchange), a blockchain-based health information exchange. Our system streamlines the translation of unstructured clinical notes into structured billable data formats, fills up cumbersome insurance questionnaires, and secures the resulting medicolegal documents on a blockchain. AI+ROAX showcases a physician-in-the-loop workflow in which cryptographically proven finalized documents are securely shared with patients, who have self-custody of their own data. We highlight innovative features such as patient-controlled modular data sharing and how AI+ROAX could be an enabler for decentralized research on health records. AI+ROAX represents a practical implementation of next-generation technologies to enhance efficiency, security, and trust in healthcare claims administration, and advance patient-centric autonomy and data portability in a globalized, mobile world.

1 Introduction

Today, clinicians are increasingly consumed by administrative tasks, diverting valuable time away from patient care. A substantial portion of this work involves documenting clinical encounters and completing medical reports and questionnaires for insurance companies [2]. This process is not only time-consuming, but also fraught with challenges, including interoperability issues caused by fragmented IT systems, the need for manual translation of clinical notes into standardized codes, and a fundamental lack of trust in the authenticity of claims [7]. These inefficiencies contribute to rising healthcare costs and delays in patient reimbursement [9].

To address these critical issues, we have developed AI+ROAX, a platform that synergizes the capabilities of generative artificial intelligence with the security and immutability of blockchain technology. AI+ROAX is an integration of a sophisticated AI agent with the Rods of Asclepius Exchange (ROAX), an open-source, blockchain-powered health information exchange that we built with Ethereum's technology.

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Our platform, AI+ROAX, demonstrates a working health informatics infrastructure that may be fully integrated with electronic medical record systems. The system automates the AI-accelerated, physician-in-the-loop generation of insurance claims documentation, ensures its integrity through cryptographic proofs, and facilitates its secure and verifiable exchange among all stakeholders. Overall, this is a practical application that reduces administrative friction, empowers patients with control over their data, and builds a foundation of trust for a more efficient healthcare ecosystem. Furthermore, AI+ROAX is financially self-sustaining based on robust principles of tokenomics adapted from the Ethereum blockchain. The blockchain infrastructure naturally provides financial incentives for stakeholders in the healthcare system to cooperate and collaboratively secure the blockchain's universal health record.

2 Background and Problem Statement

The journey of a health insurance claim is notoriously complex and inefficient. Physicians face an overwhelming administrative burden, as they must translate intricate patient encounters into structured reports and complete customized questionnaires for a variety of insurance providers [1]. This manual data entry process is not only redundant and error-prone but also a significant contributor to physician burnout.

A further complication arises from the lack of trust and verification in the system [3]. Insurance companies are required to trust that the medical reports they receive are authentic and that the claims submitted are genuine. The verification process is typically multistep and manual, resulting in delays and fostering adversarial relationships between providers and payers due to the absence of a single, immutable source of truth.

Healthcare institutions also contend with fragmented systems and interoperability challenges [4]. The widespread use of diverse Electronic Medical Record (EMR) systems, each with its own data formats and standards, creates substantial barriers to seamless data exchange. This fragmentation imposes additional administrative burdens on staff, who must reconcile information across incompatible platforms.

To address these challenges, the industry often relies on costly intermediaries, such as third-party coders and middlemen [6]. These entities are responsible for translating unstructured clinical notes into standardized International Classification of Diseases (ICD) codes and certifying the validity of reports. While their involvement is necessary under current conditions, it introduces significant overhead and ultimately increases healthcare costs for all stakeholders.

3 Opportunity

Recent technological advancements present a unique opportunity to fundamentally re-engineer this outdated process.

Generative Artificial Intelligence: Large language models (LLMs) possess a remarkable ability to understand, summarize, and transform unstructured text [10]. This creates an opportunity to develop AI agents that can assist clinicians and coders by automatically translating free-text clinical notes into structured, billable ICD codes and accurately filling up insurance claims forms. This relieves administrative burden for clinicians and frees up their time to focus on higher-value tasks.

Advanced Cryptography for Trust and Privacy: Concurrent advances in cryptography offer robust solutions that secure sensitive health data and guarantee its integrity. Two key technologies are:

- **Homomorphic Encryption**: This technique allows computations to be performed directly on encrypted data. In the context of health insurance, it could enable analytics on sensitive patient data without ever decrypting it, preserving privacy [8].
- **Zero-Knowledge Proofs (ZKPs)**: These protocols allow one party to prove to another that a statement is true without having to reveal any information beyond the validity of the statement itself, and as such this may have potential applications in healthcare, where data is often of a sensitive nature [5]. For example, a ZKP could be used to prove that a patient's claim meets an insurer's criteria without revealing the underlying sensitive clinical details.

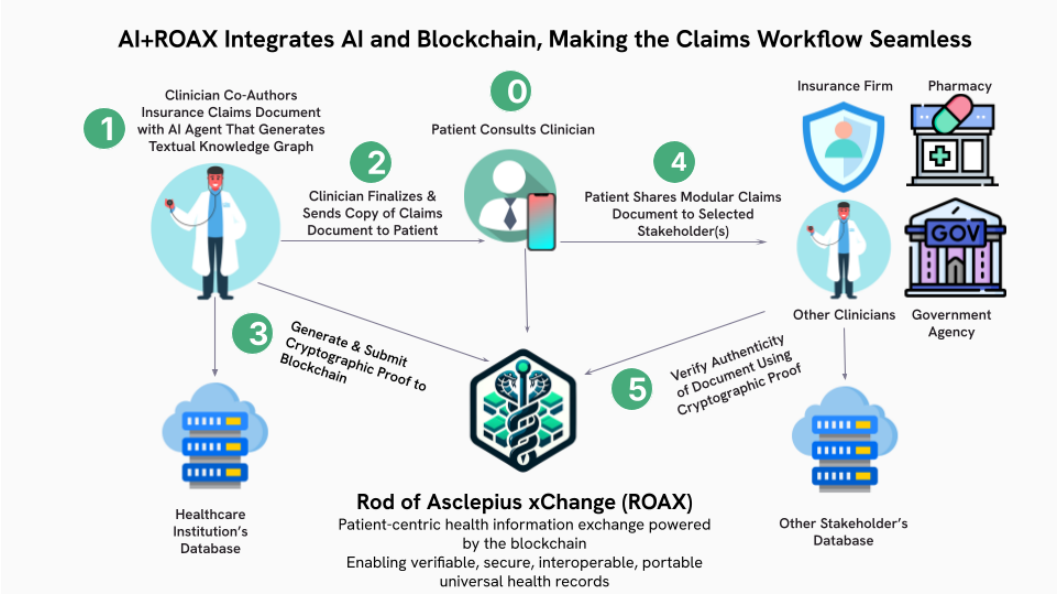

Figure 1: AI+ROAX is an integrated AI and blockchain solution that allows patients to securely share programmable modular claims documents with other stakeholders in the healthcare ecosystem. The documents are universally portable and verifiable on the blockchain.

4 The AI+ROAX Solution

We propose AI+ROAX, an integrated platform that combines a generative AI agent with ROAX, our blockchain-based health information exchange (Figure 1). This integrated AI and blockchain solution empowers patients and providers to securely exchange verifiable and portable sensitive health insurance information.

The system architecture manages the end-to-end lifecycle of an insurance document from its creation to its verification, and being fully compatible with Ethereum, the system also supports secure and efficient payment and reimbursement processes. Leveraging AI for efficiency and blockchain for security, the workflow is designed to keep the clinician in control of the accuracy of the health data, and the patient in full control of how this data is shared.

5 The Demonstration

Our demonstration showcases how the AI+ROAX platform enables the creation of a verifiable health insurance document that is programmable, secure, and interoperable.

Step 1a: AI-Powered Translation of Clinical Notes

The process begins when a clinician inputs unstructured clinical notes into the platform. The AI agent, which can be customized by the healthcare professional and guided by specific questionnaires from insurance companies, parses the text. It identifies key clinical entities, diagnoses, and procedures, translating them into structured data.

Step 1b: Generation of a Textual Knowledge Graph

To ensure transparency, the agent generates a textual knowledge graph that visually maps its reasoning. This graph follows the clinician's thought process, linking symptoms to diagnoses and treatments. This makes the AI's output interpretable and allows the clinician to quickly validate the agent's understanding of the clinical narrative.

Step 2: Form Generation with a "Physician-in-the-Loop"

Using the structured data, the AI agent automatically completes the required insurance questionnaire. The draft form is then presented to the healthcare professional for review. This critical "physician-in-

the-loop" step ensures that the final document is clinically accurate and validated by a human expert. The clinician can edit, amend, or approve the form before finalization.

Step 3: Cryptographic Proof and Blockchain Submission

Upon finalization by the physician, the AI+ROAX platform engages an API to generate a cryptographic proof (e.g., a checksum or hash) of the completed questionnaire. This unique proof is submitted as a transaction to the ROAX blockchain, creating an immutable and permanently timestamped record of the document at that exact state.

Step 5: Secure Distribution and Verification

The completed questionnaire is then securely transmitted to the insurance company, and a copy is deposited into the patient's personal mobile health wallet. Recipients can instantly verify the authenticity and integrity of the document by comparing its cryptographic checksum with the proof recorded on the blockchain. Any tampering would result in a mismatch, immediately invalidating the document.

6 Key Innovations and Features

AI+ROAX introduces several features that distinguish it from traditional methods of health data exchange.

Programmable and Modular Data Sharing

Unlike traditional health records that are shared in an "all or none" approach as monolithic data stores, data on AI+ROAX is programmable and patients may choose to share selected components of a health record. Specifically, patients are given granular control over their information, which they can share in a modular manner. For instance, in response to an insurer's request for clarification about a hospital admission following a road traffic accident, a patient can choose to share diagnostic and procedural information with an insurer while obfuscating sensitive fields such as genetic test results that may not be relevant to the current claim. This selective disclosure is a unique feature enabled by our blockchain integration, as the cryptographic proof can still validate the entire original document even when only selected components are shared. The authenticity and verifiability of the shared information is not compromised even though only

Empowering Decentralized Research

Because healthcare data on the blockchain is trusted, programmable, and verifiable, our platform serves as a foundation for research innovation. Research institutions can build decentralized applications (DApps) that request access to de-identified patient data. Patients can opt-in, and the blockchain provides a transparent, auditable trail of consent and data usage, ensuring that data is used only for its intended purpose.

Seamless Claims and Payments

By providing a single source of truth that is trusted by both providers and payers, AI+ROAX makes the claims verification process more seamless. This increased trust encourages insurance policies to be honored and payments to be made without delay, benefiting both patients and healthcare institutions.

Making Healthcare Data Storage More Robust and Cost-Effective

With AI+ROAX, patients now own secure, blockchain-verifiable copies of their health records. Apart from promoting patient autonomy, our platform also serves as a "data insurance" plan for healthcare institutions, especially smaller clinics and hospitals with less robust data management platforms that may be more susceptible to malware or ransomware attacks. Since patients have their own data and this data is also stored in each institution's database, the risk of data loss is distributed. Furthermore, since the source of health information is more likely to be directly from the patient rather than each institution's isolated, siloed electronic medical record, we envision that healthcare institutions may pursue more cost-effective data management approaches such as storing some healthcare data, especially for "stale" records, in cold storage rather than hot storage, which is more expensive.

7 Conclusion and Further Work

We have successfully demonstrated AI+ROAX, a platform that integrates generative AI with blockchain to address long-standing inefficiencies in the health insurance claims process. Our solution reduces the administrative workload on physicians, enhances the security and integrity of sensitive health data, and empowers patients with unprecedented control over their information.

Further work will focus on expanding the platform to support a wider array of insurance forms and clinical specialties. We will also explore the integration of more advanced cryptographic methods, such as ZKPs, to enable privacy-preserving verification of claims. A key next step is to launch pilot studies with partner institutions to quantify the efficiency gains and economic impact of AI+ROAX in a real-world setting.

8 Limitations and Challenges

While AI+ROAX streamlines insurance documentation and enhances data security, its effectiveness depends on the quality and consistency of input clinical notes. Variability in clinician documentation styles and incomplete records may lead to inaccurate or incomplete form generation. To mitigate this, the platform could incorporate adaptive AI models trained on diverse datasets and provide real-time feedback or prompts to clinicians to improve data completeness and standardization.

Another limitation is the reliance on blockchain infrastructure, which may introduce scalability and latency challenges as transaction volumes grow. High throughput and low-latency requirements in healthcare settings could be difficult to meet with current blockchain technologies. Mitigation strategies include leveraging scalable layer-2 solutions, optimizing consensus mechanisms, or selectively recording only critical proofs on-chain while storing bulk data off-chain with secure references.

Finally, patient-controlled granular data sharing, while empowering, may inadvertently lead to underdisclosure of clinically relevant information, affecting claim outcomes or research validity. To address this, the system could implement guided sharing workflows, educate users on the implications of selective disclosure, and provide default templates that balance privacy with necessary transparency for insurance and research purposes.

9 Call to Action

We believe that a collaborative ecosystem is essential for transforming healthcare administration. We invite stakeholders to join us:

- **Insurance Companies:** Partner with us to integrate your claims processing workflows and questionnaires into the AI+ROAX platform. Your participation in pilot programs will be invaluable in validating the system's effectiveness and shaping its future development.
- **Healthcare Institutions:** We encourage you to join our pilot program. Empower your clinicians with a tool that reduces administrative burnout, secures patient data, and streamlines revenue cycle management.
- **Patients:** Advocate for technologies that grant you ownership and control over your personal health information. Support platforms like AI+ROAX that are built on principles of privacy, security, and patient empowerment.

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