Resilient Blockchain Infrastructure for Decentralized AI

Sarah Kim
Dept. of Engineering
Some State University
Some City, A State, USA
SarKim@ssu.edu

David Liu
Dept. of Engineering
Some State University
Some City, A State, USA
DLiu@ssu.edu

Jane Smith
Dept. of Engineering
Some State University
Some City, A State, USA
JaneSmith@ssu.edu

***Abstract*—This paper presents a blockchain architecture designed specifically to support decentralized artificial intelligence (AI) applications operating across edge environments. Traditional blockchain systems suffer from latency and scalability limitations that hinder real-time AI processing. We propose a lightweight consensus algorithm tailored for asynchronous AI model updates, combined with a modular integrity layer that ensures tamper-resistant data provenance. Our experimental results demonstrate enhanced fault tolerance, reduced consensus time, and improved throughput in simulations of adversarial network conditions. These findings suggest that blockchain, when reengineered for AI-specific constraints, can provide a resilient backbone for distributed intelligent systems.**

I. Introduction

The integration of blockchain technology with decentralized artificial intelligence (AI) introduces new opportunities and challenges for distributed computation. As AI systems increasingly migrate from centralized data centers to the edge—in smart devices, IoT networks, and embedded systems—the need for secure, autonomous coordination becomes paramount.

Traditional blockchains offer immutability, transparency, and trust without central authority. However, they are not inherently optimized for the computational and communication patterns characteristic of AI workflows. AI training and inference often involve rapid model updates, large-scale data exchanges, and high-frequency synchronization—all of which conflict with the latency and throughput constraints of legacy blockchain protocols such as Proof-of-Work and Proof-of-Stake.

In this work, we present a blockchain infrastructure specifically engineered to address these limitations. Our system introduces a lightweight consensus mechanism, resilient to partial node failure and adversarial interference, that supports dynamic participation and asynchronous operation. Additionally, we embed a data integrity layer to ensure tamper-evident transmission of model parameters and learning updates, even in untrusted environments.

The rest of this paper is organized as follows. Section II surveys related efforts in decentralized AI and blockchain integration. Section III outlines our system architecture and core design principles. Section IV details our evaluation methodology and performance benchmarks. We conclude in Section V with a discussion on deployment challenges and future research directions.

II. Related Work

The intersection of blockchain and artificial intelligence has gained attention in recent years, primarily in areas related to data provenance, federated learning coordination, and decentralized model marketplaces. Early projects such as Ocean Protocol and SingularityNET demonstrated the feasibility of decentralized AI ecosystems, enabling AI agents to transact and share models on-chain. However, these systems often inherit the limitations of their underlying blockchains, particularly in latency-sensitive scenarios.

Several academic efforts have explored federated learning over blockchain networks. For instance, Zhang et al. [1] proposed a federated averaging scheme supported by smart contracts, while Li and Huang [2] examined the role of consensus algorithms in mitigating model poisoning attacks. Despite their innovations, these approaches rely heavily on general-purpose blockchain platforms that are not designed for the dynamic requirements of AI model training.

Recent attempts to optimize blockchain specifically for edge AI have focused on minimizing consensus overhead. Lightweight DAG-based protocols (e.g., IOTA, Nano) and hierarchical blockchains have shown promise in reducing latency, though they often sacrifice security guarantees or decentralization in the process.

In contrast, our work introduces a blockchain architecture purpose-built for decentralized AI, combining a streamlined consensus layer with protocol-level resilience features. We emphasize operational robustness in adversarial network conditions and design for the practical constraints of edge computing environments.