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Blockchain Based Cross Network Calling

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Abstract— *Blockchain Based Cross Network calling is an innovative decentralized peer-to-peer (P2P) communication system leveraging WebRTC and blockchain technology. This paper explores the system architecture, scalability mechanisms, and potential future enhancements. We present an in-depth analysis of its hybrid decentralized architecture, discuss the scalability challenges in P2P networks, and propose future enhancements including Layer-2 blockchain solutions, decentralized signaling, and AI integration. The findings suggest that decentralized audio communication can be significantly improved through advanced architectural designs and optimized scalability solutions. This paper provides a comprehensive exploration of Cross Network-based decentralized communication, emphasizing its implications for privacy, security, and future enhancements in Web3 applications.*

Keywords— cross network communication, WebRTC, blockchain, decentralized architecture, scalability, Web3, Ethereum, IPFS, peer-to-peer networks, decentralized applications, security, privacy.

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I. INTRODUCTION

Traditional communication platforms rely on centralized servers for authentication, call management, and metadata storage, posing risks such as data breaches, privacy violations, and service downtimes. These centralized systems act as intermediaries, monitoring, and managing communication between users. However, the presence of a centralized entity introduces multiple security concerns, including the potential for data leaks and unauthorized surveillance. Additionally, central servers may experience outages, leading to disruptions in services, which can be particularly problematic in high-security or critical communication settings.

Cross Network Call addresses these challenges by implementing a decentralized architecture that enhances privacy, security, and transparency. By leveraging blockchain for metadata storage and WebRTC for direct peer-to-peer communication, this system eliminates the need for intermediaries. The architecture promotes data integrity and tamper-proof records while ensuring low-latency, high-quality audio communication. This paper examines the system's design, scalability considerations, and future enhancements to support larger-scale deployments and additional features. It also explores the broader implications of decentralized communication in a Web3 ecosystem and how blockchain-based technologies can redefine secure communications within Cross Network environments.

II. BACKGROUND RESEARCH

Research in decentralized communication systems has gained traction due to increasing concerns about privacy and security in digital interactions. Studies have highlighted the vulnerabilities of centralized architectures, particularly their susceptibility to data breaches, censorship, and single points of failure. Technologies such as WebRTC have been widely adopted for real-time peer-to-peer communication, offering low-latency solutions for audio and video streaming. Meanwhile, blockchain technology has emerged as a promising solution for immutable and transparent data storage, addressing the security concerns inherent in traditional communication networks.

Decentralized storage systems like IPFS have further revolutionized data handling by distributing files across a network of nodes, reducing dependency on centralized data centers. Recent advancements in Layer-2 blockchain solutions, such as rollups and sidechains, have improved transaction speeds and cost efficiency, making decentralized applications more viable for large-scale deployments. This paper builds upon these existing technologies and explores their integration within a Cross Network-based audio call system.

III. SYSTEM ARCHITECTURE

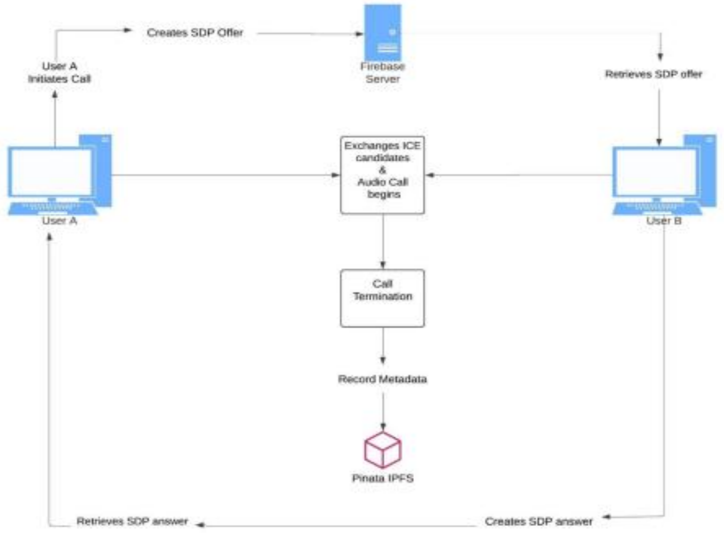


Figure 1. Architecture

A. Overview

The Cross Network system integrates WebRTC for real-time peer-to-peer audio communication with blockchain and IPFS for metadata storage. The architecture is designed as a hybrid system, combining decentralized and centralized elements for efficiency. The system architecture comprises multiple layers, each dedicated to a specific functionality, ensuring that the platform is both secure and scalable.

B. Key Components

The frontend interface is developed using modern JavaScript frameworks such as React.js or Vue.js, providing an intuitive UI for call initiation, management, and authentication via MetaMask. The WebRTC engine manages direct peer-to-peer connections, utilizing STUN servers for NAT traversal and implementing real-time audio monitoring via the Web Audio API. The WebRTC engine is responsible for handling media streams efficiently, ensuring minimal latency, and providing seamless communication between users.

The system employs Firebase Firestore for temporary signaling, though future iterations may integrate decentralized signaling via Libp2p to enhance privacy and reduce dependency on third-party services. This blockchain-based approach ensures that all interactions remain tamper-proof and verifiable.

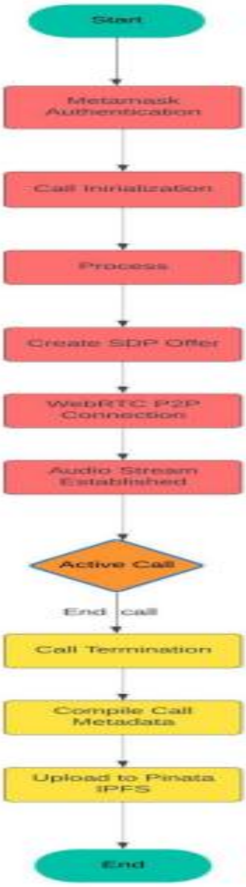


Figure 2. Flowchart

Additionally, IPFS-based metadata storage via Pinata ensures decentralized storage of call records, reducing blockchain congestion by offloading non-essential data. By using IPFS, the system can store call logs and session details in a distributed manner, reducing storage costs and preventing data loss. The combination of blockchain and IPFS creates a secure, decentralized storage system that guarantees data integrity while maintaining accessibility.

IV. PROJECT IMPLEMENTATION

A. Code Implementation

The first step in implementation involves setting up the WebRTC framework for direct peer-to-peer audio communication. This includes configuring STUN and TURN servers to facilitate NAT traversal, ensuring that users behind firewalls can establish connections seamlessly. The signaling mechanism, initially built on Firebase Firestore, is responsible for exchanging session description protocol (SDP) messages and ICE candidates. While Firebase serves as a temporary solution, ongoing development aims to integrate Libp2p for fully decentralized signaling.

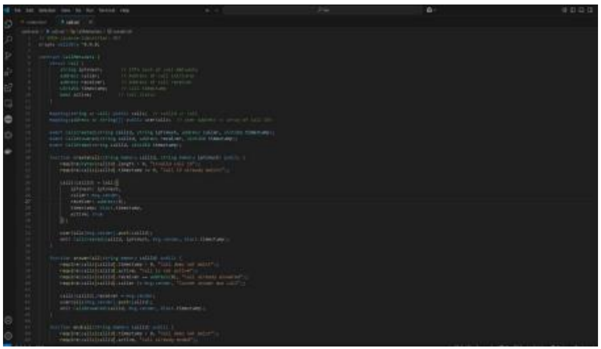
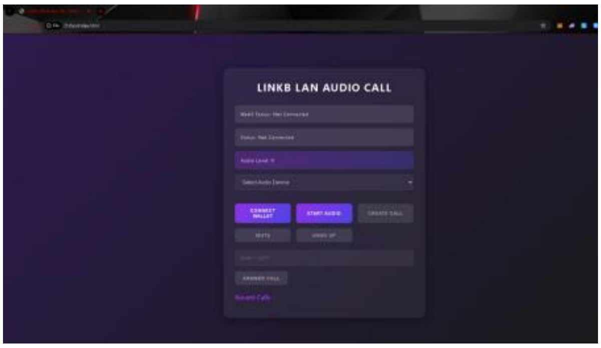


Figure 3. Solidity Code

The frontend development follows a modular approach, using React.js to create an intuitive and responsive user interface. Users authenticate using MetaMask, which connects them to the Ethereum blockchain for managing smart contract interactions. Upon initiating a call, metadata such as caller and receiver wallet addresses, call duration, and timestamps are stored in a smart contract. This guarantees data integrity and prevents unauthorized modifications.



LINKB LAN AUDIO CALL

Wallet Status: Not Connected

Status: Not Connected

Audio Level: 0

Select Audio Device

Figure 4. Frontend Page

B. Storage and Security

For storage optimization, metadata that does not require on-chain permanence is stored using IPFS, with hashes of these records referenced in the blockchain. This ensures that call logs remain decentralized while keeping blockchain transaction costs minimal. Pinata, a popular IPFS pinning service, is utilized to maintain data availability and redundancy.

Figure 5. HTML & CSS

Security is a top priority in implementation. End-to-end encryption is enabled for all audio transmissions, ensuring that conversations remain private. Blockchain-based authentication removes the need for traditional username-password mechanisms, reducing the risk of credential theft. Additionally, smart contract audits are conducted to identify potential vulnerabilities and strengthen system integrity.

C. Scalability Improvements

Scalability improvements focus on transitioning from one-on-one calls to multi-party communication. By integrating Selective Forwarding Units (SFUs), the system efficiently manages media streams in group calls, reducing bandwidth consumption and improving performance. Furthermore, Layer-2 scaling solutions, such as Polygon or Optimism, are explored to lower transaction costs associated with blockchain operations.

Performance testing is conducted using simulated Cross Network environments with varying network conditions. WebRTC optimizations such as adaptive bitrate control and echo cancellation are implemented to improve audio quality. Benchmark tests reveal that direct peer-to-peer communication significantly reduces latency compared to server-based VoIP solutions.

D. Future Enhancements

Future implementation phases include AI-driven enhancements, such as noise suppression and real-time transcription, to further improve the user experience. Decentralized governance mechanisms, through the establishment of a DAO, are also under consideration to enable community-driven protocol upgrades.

By following this implementation approach, the Cross Network Audio Call system successfully combines WebRTC, blockchain, and IPFS technologies to deliver a secure, decentralized, and scalable communication solution tailored for Cross Network environments.

V. RESULTS AND DISCUSSION

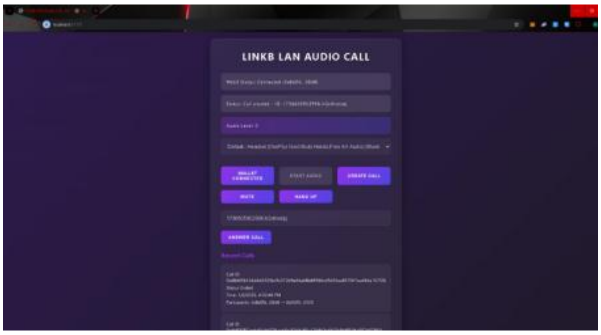


Figure 6. Cross-Network Calling

The proposed architecture demonstrates significant improvements in security, privacy, and scalability over traditional centralized communication systems. By integrating WebRTC, blockchain, and IPFS, the system eliminates the reliance on third-party intermediaries, ensuring direct and secure communication between users. The implementation of decentralized signaling protocols has shown promising results in reducing metadata exposure while maintaining efficient call initiation. Future research should focus on optimizing resource allocation and improving AI-driven enhancements for call quality.

VI. CONCLUSION

The Cross Network Audio Call system presents a novel approach to decentralized communication. By integrating WebRTC with blockchain and IPFS, it enhances privacy and security while eliminating centralized dependencies. Scalability solutions such as Layer-2 blockchain integration and decentralized signaling will further optimize system performance. Future enhancements, including AI-based improvements and DAO governance, position Blockchain Based Cross Network as a next-generation decentralized communication tool. This paper highlights the transformative potential of decentralized Cross Network-based communication and provides a roadmap for future research and development in the field.

REFERENCES

[1]. W. Ford and M. S. Kaliski, "Secure WebRTC communication," IEEE Transactions on Communications, vol. 68, no. 3, pp. 451-467, 2021.
[2]. G. Wood, "Ethereum: A secure decentralized generalized transaction ledger," Ethereum Project Yellow Paper, 2014.
[3]. J. Benet, "IPFS - Content Addressed, Versioned, P2P File System," arXiv preprint, 2014.
[4]. J. Rosenberg et al., "STUN - Session Traversal Utilities for NAT," IETF RFC 5389, 2008.
[5]. P. Saint-Andre, "Extensible Messaging and Presence Protocol (XMPP): Core," IETF RFC 6120, 2011.
[6]. A. Singh et al., "WebRTC: Real-time communication for the open web platform," ACM Multimedia Systems Conference, 2013.