

Chapter 4

Blockchain Interoperability: Protocols, Frameworks, and Practical Implications

Alice Jain

Manipal University Jaipur, India

Kavita Jhajharia

 <https://orcid.org/0000-0002-6424-2127>

Manipal University Jaipur, India

ABSTRACT

Blockchain technology has gained significant attention for its potential to revolutionize various industries by offering decentralized and immutable data storage and transaction mechanisms. This book chapter investigates the critical issue of blockchain interoperability and evaluates various solutions proposed to address this challenge. The chapter begins by providing an overview of blockchain interoperability, highlighting its importance in realizing the full potential of blockchain technology. It discusses the limitations of existing blockchain networks and described the need of interoperability. The chapter delves into an in-depth analysis of different approaches to achieve blockchain interoperability. These include interoperability protocols such as atomic swaps, sidechains, notary schemes, hashed time locks and cross-chain communication protocols, as well as interoperability frameworks. Finally, this chapter underscores the significance of blockchain interoperability as a catalyst for the widespread adoption and integration of blockchain technology into existing infrastructures.

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1. INTRODUCTION

1.1 Overview of Blockchain

In an increasingly digitized world, there is an upsurge in the demand for secure, transparent, and efficient systems for recording and verifying transactions and data. Amidst this, blockchain technology has emerged as a revolutionary breakthrough that has the ability to disrupt sectors and transform how we do business, manage information, and establish trust lessness. Blockchain technology has been gradually incorporated into many facets of day-to-day life and has greatly benefitted economically and socially in several sectors, including finance, the Internet of Things (IoT) (*Sensors | Free Full-Text | Adaptation of IoT with Blockchain in Food Supply Chain Management: An Analysis-Based Review in Development, Benefits and Potential Applications*, n.d.), healthcare (*An Advanced Blockchain-Based Hyperledger Fabric Solution for Tracing Fraudulent Claims in the Healthcare Industry - ScienceDirect*, n.d.; *Blockchain in Healthcare and IoT: A Systematic Literature Review - ScienceDirect*, n.d.; *Sensors | Free Full-Text | A Novel Blockchain-Based Healthcare System Design and Performance Benchmarking on a Multi-Hosted Testbed*, n.d.; Sutradhar et al., 2024), public goods (*An Advanced Blockchain-Based Hyperledger Fabric Solution for Tracing Fraudulent Claims in the Healthcare Industry - ScienceDirect*, n.d.), agriculture (Hasan et al., 2023), and the energy industry (Gawusu et al., 2022).

Blockchain became increasingly popular after the year 2008, when Satoshi Nakamoto formulated the idea of Bitcoin in his white paper titled “A Peer-to-Peer Electronic Cash System” in which he made significant modifications to the Merkle Tree model, resulting in a more secure system that records the tamper-proof history of data exchanges. This system operates through a peer-to-peer network that uses timestamping. Nakamoto's innovation proved to be immensely valuable, establishing cryptography as a fundamental component of the Blockchain (Nakamoto, n.d.).

The majority of blockchains are programmable, allowing users to extend their state machine with custom applications. These applications, frequently referred to as smart contracts, are executed through triggers, also referred to as transactions. Smart contracts operate within a virtual computer, such as the Ethereum Virtual computer or EVM. Ethereum as well as other blockchains that utilize EVM for compatibility are known as EVM-based blockchains (Lisi et al., 2023). Tokens, which are blockchain-based representations of various assets like cash, assets, equity, identity etc., are frequently implemented via smart contracts. ERC-777 and ERC-721 are two examples of standard token formats. These tokens can be either fungible or non-fungible assets. Fungible assets can be exchanged for other assets of the same type, while non-fungible assets are unique and possess specific properties (Ali et al., 2023).

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