Blockchain Simulator – Project Report

Abstract

Blockchain technology has revolutionized the way digital transactions are recorded and validated. Unlike centralized systems, blockchain provides a decentralized, transparent, and secure ledger that prevents tampering and fraud.

This project implements a **Blockchain Simulator in Java** to illustrate these concepts. The simulator allows users to create transactions, mine blocks with proof-of-work, and validate the blockchain. It also outputs the blockchain state in JSON format, making it easy to visualize and understand the underlying data structures.

Introduction

The goal of this project is to provide a **hands-on understanding of blockchain fundamentals**. In real-world systems like Bitcoin and Ethereum, blockchain manages digital currency transactions securely without central authority.

Our simulator replicates these core features in a simplified environment:

- **Block Structure** – Each block contains data, a timestamp, a hash, and the hash of the previous block.

- **Proof-of-Work (Mining)** – New blocks are added only after solving a computational puzzle.

- **Transactions** – Users can create custom transactions, which are recorded in new blocks.

- **Chain Integrity** – Each block is linked to the previous one, ensuring immutability.

This simulator helps students and beginners understand the workflow of blockchain without needing advanced cryptographic or network concepts.

Tools Used

Java 17 – Core programming language.
- Gson Library (Google) – For displaying the blockchain as formatted JSON.
- Command Line (javac/java/jar) – For compiling, packaging, and running the project.
- draw.io / diagrams.net – Used for creating the blockchain flow diagram.

Steps Involved in Building the Project

1. Block Class – Stores data such as transactions, timestamp, previous block hash, and nonce. Generates block hash using SHA-256.
2. Blockchain Class – Maintains the list of blocks, handles difficulty level, mining process, and validation.
3. Transaction Structure – Allows users to input sender, receiver, and amount. Pending transactions are pooled until mined into a block. Miners are rewarded with cryptocurrency.
4. Proof-of-Work – A block is mined only when its hash starts with leading zeros (difficulty level). Mining requires trial-and-error computation of nonce values.
5. Chain Validation – Ensures each block's hash matches its calculated hash and previous hash reference.
6. User Interaction (Console Menu) – Create transactions, mine, view blockchain, validate chain.
7. JSON Output – Displays blockchain data in structured format for readability.

Conclusion

The Blockchain Simulator project demonstrates the core mechanics of blockchain technology in a simplified, educational environment. It covers:
- Cryptographic hashing (SHA-256).
- Proof-of-Work mining process.
- Transaction management.
- Chain validation and immutability.
- JSON-based blockchain visualization.

Through this project, users gain practical knowledge of how decentralized ledgers function, why mining is computationally expensive, and how integrity is maintained across the chain. This foundation can be extended further to include features like digital signatures, peer-to-peer networking, and smart contracts, bridging the gap between basic blockchain concepts and real-world applications like Bitcoin and Ethereum.