Data Structures
CS-2001

Project Report
“Data Integrity In Supply Chain Management”

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Introduction

This project is programmed to encounter the real-life problem of data integrity in the supply chain management system: the management of tokens and products within a supply chain. Using C++ programming, this system leverages data structures like **trees (Merkle Tree), maps, vectors, arrays and structs, and Hashing (SHA-256 Algorithm)** to represent tokens, products, and their transactions. The system facilitates token issuance, product tracking, ownership transfers, and balance management. Additionally, it incorporates **cryptographic functionalities such as SHA-256 hashing and Merkle tree construction** to ensure data integrity and security in token transactions. Through this project, the efficiency and security of supply chain operations are enhanced, providing a robust framework for managing assets and transactions across different entities in a supply chain ecosystem.

Motivation

The motivation for this project was just an overlying problem-solving passion in us which ignited us to solve a problem of this Supply Chain Management data integrity and payment issues. We also wanted to explore the blockchain, so this was an amazing opportunity for us to complete our Data Structures project alongside learning blockchain and cybersecurity concepts, and integrating those in our project to make the most out of the project.

Features Of The Project

1. Token Management

- **Token Issuance:** Ability to issue new tokens with unique identifiers, initial balances, and ownership details.
- **Token Transfer:** Facilitates the transfer of tokens between different owners while ensuring balance integrity and ownership verification.
- **Balance Tracking:** Tracks and manages token balances for each owner, allowing efficient monitoring of asset distribution.

2. Product Management

- **Product Issuance:** Allows for the issuance of new products with distinct IDs, descriptions, and initial ownership details.
- **Ownership Transfer:** Enables the transfer of product ownership between entities within the supply chain, ensuring accountability and tracking of product movements.

3. Transaction Handling

- **Token Transactions:** Manages transactions related to tokens, including transfers between owners and balance updates, ensuring secure and accurate record-keeping.
- **Product Transactions:** Tracks and records transactions involving product transfers, providing a clear audit trail of ownership changes and product movements.

4. Cryptographic Security

- **SHA-256 Hashing:** Utilizes the SHA-256 cryptographic hash function for data integrity and security, ensuring that transactional data remains tamper-resistant and verifiable.
- **Merkle Tree Implementation:** Constructs Merkle trees to organize and validate token transaction data, enhancing data integrity and facilitating efficient verification of transaction histories.

5. Reporting and Monitoring

- **Token Balance Monitoring:** Provides functionalities to monitor token balances for different owners, allowing for real-time visibility into asset distribution and utilization.
- **Transaction History:** Maintains comprehensive transaction histories for tokens and products, supporting detailed reporting and analysis of supply chain activities.

6. Efficiency and Scalability

- **Efficient Data Structures:** Utilizes efficient data structures such as maps, arrays, and structs to manage token, product, and transactional data, ensuring optimal performance and scalability.

- **Optimized Algorithms:** Implements optimized algorithms for token transfer, ownership validation, and Merkle tree construction, enhancing system efficiency and responsiveness.

7. Security Measures

- **Ownership Verification:** Implements ownership verification mechanisms to ensure that only authorized users can perform token and product transactions, maintaining data security and integrity.
- **Data Encryption:** Integrates data encryption techniques to protect sensitive information, safeguarding against unauthorized access and data breaches.

8. Extensibility and Customization

- **Modular Architecture:** Designed with a modular architecture that supports easy customization and extension of functionalities, allowing for the integration of additional features and enhancements as needed.

Challenges Faced

1. Blockchain Integration

- Implementation of basic and efficient Supply Chain Management was an easy task for us. We mainly struggled with the Blockchain integration part which includes SHA-256 and Merkle Tree integration. Grasping these difficult concepts and then implementing those in C++ was a difficult task but we did it.

2. Data Structures

- Our main motive was to choose a data structure that's the best one for this case scenario. We did a thorough analysis and research before selecting any data structures, but we finally did our best and gave our best in this selection.

3. Error Handling and Validation

- Implementing error handling mechanisms and data validation procedures to detect and handle exceptions, validate user inputs, and ensure data consistency and security have been a significant challenge too.

4. GUI Implementation

- To make it look good, we tried to implement GUI, but it was taking too much time, so we decided to drop this from our plan and focus mainly on the project and its real-life problem solving implementation.

Conclusion

In summary, the Supply Chain Management project has been successfully completed, providing a comprehensive solution for managing tokens, products, and transactions within a supply chain environment. The project addressed challenges in data management, algorithm design, cryptographic security, user interface, error handling, and scalability. Through diligent development efforts, the system now offers functionalities such as token issuance, transfer, product tracking, ownership verification, and secure transaction management. The project not only demonstrated technical expertise in software development and cryptography but also showcased effective problem-solving, teamwork, and project management skills. The system stands ready for deployment and further enhancements, contributing to improved efficiency, transparency, and security in supply chain operations.
