Literature Review: Blockchain-Based Supply Chain Management

Abstract

This literature review explores how blockchain technology is revolutionizing the supply chain domain by enhancing transparency, traceability, and operational efficiency. Drawing upon insights from mentioned articles in the Google Form and the real-world implementation of SilkRoad, our solution for the Smart India Hackathon 2024 Finals, the review investigates key challenges in traditional supply chains and demonstrates how blockchain-based systems can address them. The paper concludes by outlining the system architecture, performance features, and potential for scalability.

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1. Introduction

Traditional supply chains often lack transparency, are prone to inefficiencies, and face risks of fraud or counterfeit. With the growing need for trust, especially in healthcare and pharmaceuticals, blockchain presents an ideal solution due to its decentralized, tamper-proof nature. This paper surveys current research trends and concludes with the development of SilkRoad, a blockchain-based SCM system designed to combat these very issues.

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2. Literature Review

2.1 Benefits of Blockchain in SCM

Feature	Traditional SCM	Blockchain SCM
Data Integrity	Prone to manipulation	Immutable
Transparency	Limited visibility	Real-time shared ledger
Traceability	Paper/manual tracking	End-to-end traceability
Operational Efficiency	Manual verification	Automated via smart contracts
Fraud Risk	High	Significantly reduced

2.2 Major Supply Chain Challenges & Blockchain Solutions

Challenge	Impact	Blockchain-Based Solution
Counterfeit Drugs	Patient safety risk	Unique hashes & immutable recordkeeping
Fragmented Stakeholder Data	Inefficiencies in coordination	Shared distributed ledger

Manual Verification of Shipments	Time and labor-intensive	Smart contract automation
Limited Forecasting Capabilities	Overstock or understock	On-chain data analytics
Recall Management	Delays, imprecision	Real-time tracking of batches

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3. Our SIH 2024 Project: SilkRoad

SilkRoad is a blockchain-based decentralized platform developed to address pharmaceutical supply chain problems by leveraging Ethereum smart contracts, role-based access controls, and advanced analytics.

3.1 Role-Based Access Control (RBAC)

Role	Privileges
Contract Owner	Add new medicines, manage access
Raw Material Supplier	Upload raw material info
Manufacturer	Update batch production details
Distributor	Enter distribution and shipment updates
Retailer	Confirm product receipt, display status
Hospital	Register, request medicines, return expired drugs

3.2 Features Overview

- **Add Medicine**: Only contract owner can add verified medicines.
- **Control Supply Chain**: Movement through roles using RBAC verified transitions.
- **Track Medicines**: Enter med ID to view real-time supply chain status.
- **Demand Forecasting**: Uses historical data and analytics to predict demand.
- **Hospital Management**: Hospitals request medicines directly on-chain.
- **Reverse Supply Chain**: Expired drugs are returned for destruction.
- **Smart Alerts**: Notifications for expiry, under/overstock, disruptions.

3.3 Dashboard Analytics

Metric	Description
Total Medicines	All active and expired medicines
Understocked / Overstocked	Inventory health at different nodes

Expiring Soon	Medicines nearing expiration
Registered Entities by Location	Visual map of participant distribution
Medicine Stage Distribution	How many medicines are at each supply chain stage
Supplier/Manufacturer/Retailer Stats	Stakeholder contribution breakdown
Expiry Distribution	Medicines nearing expiry by batch
Detailed Medicine Info	Batch, timestamp, participant history

Sample Visualizations to Include:

- Pie Chart: Medicine Stage Distribution
- Bar Chart: Entities by Region
- Line Graph: Expiry Forecasting Trend

3.4 Platform Architecture

- **Frontend**: React + Tailwind CSS
- **Backend**: Solidity Smart Contracts + Ethereum Sepolia Testnet
- **Database**: Off-chain storage for sensitive data (IPFS/MongoDB), hashed on-chain

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4. Scalability and Future Enhancements

While Ethereum provides secure decentralized infrastructure, its transaction throughput and gas costs can be bottlenecks.

Proposed Solutions:

- Use of Layer 2 technologies like **Optimism**, **Arbitrum**, or **Polygon zkEVM**
- Batch-processing of transactions
- Off-chain storage of large datasets, with on-chain verification

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5. Comparative Impact

KPI	Traditional SCM	SilkRoad SCM
Medicine Authentication Time	Days	Seconds (on-chain)
Manual Errors	High	Minimized
Counterfeit Detection	Low	Instant
Inventory Optimization Accuracy	Poor	High (via analytics)

Recalls Traceability	Limited	Full batch history

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6. Conclusion

The integration of blockchain in supply chain management holds transformative potential, especially in domains where transparency and security are paramount. SilkRoad, with its decentralized, role-governed, analytics-powered approach, demonstrates a viable and scalable solution to longstanding issues in pharmaceutical logistics. Our presentation of SilkRoad at the SIH 2024 Finals highlights not only its feasibility but its real-world applicability and impact.

Moving forward, enhancements via Layer 2 and machine learning-based forecasting will further elevate the system. Blockchain SCM platforms like SilkRoad have the capacity to redefine trust, automation, and coordination in global supply chains.

References

SilkRoad Platform

- SilkRoad Official Site: https://silkroad-snzu.vercel.app/
- SIH 2024 Finalist Announcement: https://kjsce.somaiya.edu/en/view-announcement/672/

Research Articles

1. Wang, Y., Han, J.H., & Beynon-Davies, P. (2023). *Understanding blockchain technology in supply chain management: A review of the literature*. Computers & Industrial Engineering. https://www.sciencedirect.com/science/article/pii/S0360835223000219
2. Reyna, A., Martín, C., Chen, J., Soler, E., & Díaz, M. (2020). *On blockchain and its integration with IoT. Challenges and opportunities*. Future Generation Computer Systems. https://ieeexplore.ieee.org/abstract/document/9316803
3. Hassani, H., Huang, X., & Silva, E. (2021). *Digital transformation and blockchain: A review*. Computers in Biology and Medicine. https://www.sciencedirect.com/science/article/pii/S0010482521008945