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Intergated Blockchain Platform for Supply Chain Information and Financial Transactions (2025)

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***Abstract*—The supply chain industry encounters numerous challenges in information sharing and financing, including data silos, a lack of transparency, and heightened fraud risks. This paper proposes a blockchain-based supply chain information operation method to address these issues effectively. By leveraging blockchain technology, the paper aims to enable seamless sharing of supply chain information and secure financial transactions. The approach involves developing a blockchain-based supply chain architecture and a hierarchical model of information flow. A method for recording information blocks sourced from internal and external data within the supply chain is proposed, incorporating advanced cryptographic algorithms and consensus mechanisms to ensure data integrity and security. The platform utilizes smart contracts to automate key processes and enforce compliance, minimizing manual intervention and reducing errors. This integrated blockchain platform enhances the connectivity and reconstruction capabilities of supply chain networks, ensuring robust information storage and access control. It also includes innovative supply chain financing solutions, such as secure financial transactions for invoice factoring and letters of credit, facilitated by blockchain technology. This integration fosters trust, reduces fraud risks, and streamlines monetary flows across the supply chain. The project promises a comprehensive business architecture that addresses information sharing and financial transaction challenges in supply chains. It seeks to achieve improved transparency, enhanced security, and operational efficiency for modern supply chain networks.**

***Index Terms*—Blockchain, Supply chain, Transparency, Smart Contracts, Financing**

I. INTRODUCTION

The supply chain industry is a complex network of interconnected stakeholders, including manufacturers, suppliers, logistics providers, and financial institutions. These networks often face significant challenges such as fragmented data systems, limited transparency, and the risk of fraud, all of which impede seamless operations and trust among participants. Moreover, financial transactions within supply chains, such as payments and financing, are often delayed and burdened by intermediaries, resulting in inefficiencies and increased costs. This paper seeks to address these challenges by harnessing the transformative potential of blockchain technology. Blockchain, with its decentralized, secure, and immutable nature, offers a robust solution for enhancing transparency, traceability, and security within supply chains. It enables the creation of a shared, tamper-proof ledger where supply chain events and financial transactions are recorded in real-time, accessible to all authorized participants. The project focuses on developing a blockchain-based platform that integrates supply chain information management with financial transaction capabilities. It includes key features such as a hierarchical information flow model, advanced cryptographic methods for data security, and smart contracts to automate processes like inventory tracking, payment settlements, and regulatory compliance. By incorporating supply chain financing solutions such as invoice factoring and blockchain-enabled letters of credit, the platform streamlines monetary flows while reducing fraud risks. This integrated approach not only enhances operational efficiency but also fosters trust and collaboration among stakeholders. The proposed platform has the potential to revolutionize supply chain networks by creating a transparent, secure, and efficient ecosystem for both information sharing and financial transactions. Through this project, we aim to bridge the gap between operational logistics and financial workflows, paving the way for more resilient and sustainable supply chains...

II. RELATED WORK

Blockchain is a technology that's being used in many fields over the years like Finance for crypto currency payments, automated transactions and decentralized exchanges, in healthcare for maintaining patient data and EHRs (Electronic Health Records), in Government and public services for secure Digital IDs, voting mechanism, fraud proof tax reporting and auditing. One of the major fields that use Blockchain as a key leverage for its operations is Supply chain. We found previous works which contributed in finding different aspects of this topic and improved it furthermore through our paper.

A. Haffar & Özceylan (2024) – Proposed a blockchain-based supplier selection system incorporating sustainability, leanness, and agility factors. They introduced a multi-attribute reverse auction mechanism and a hybrid on-chain/off-chain model to reduce blockchain transaction costs. They Compared blockchain-based supplier selection systems with traditional procurement models, emphasizing improvements in transparency, efficiency, and fraud prevention.

B. Manzoor, Sahay & Singh (2022) – Conducted an organizational-theoretic overview of blockchain in supply chains, categorizing research into four stages: pre-adoption, adoption, implementation, and application. They highlighted blockchain's role in enhancing supply chain resilience and reducing operational risks. They Identified barriers to blockchain adoption in SCM, including integration challenges, regulatory compliance, and cost concerns.

C. Chang, El-Rayes & Shi (2022) **–** Emphasized traceability as the primary driver for blockchain adoption in supply chains. They analyzed 2,265 articles and found blockchain research is expanding in SCM, healthcare, and government sectors, while declining in banking and cybersecurity. They also showcased blockchain's advantage over traditional ERP systems in tracking and managing supply chains through decentralized and immutable data storage.

2.1 OUR CONTRIBUTION:

Based on our research and knowledge we've developed and deployed a blockchain platform on Hardhat framework which integrates financial transactions along with information traceability.

i. **Integration of Financial Transactions:**
Previous studies mainly focus on tracking goods but do not address financial flows. We implemented Ethereum based transaction model which incorporates supply chain financing mechanisms such as 'Invoice Factoring' which allows suppliers to get advance payments, 'Letters of Credit' which ensures payment security between suppliers and buyers and 'On-Chain Secure Payments' where Transactions are executed via Ethereum smart contracts.

ii. **Hardhat-Based Web3 Implementation:**
We created a more deployable model which provides a functional blockchain prototype compared to theoretical models and simulations in the previous papers. Our model includes Hardhat for blockchain deployment, MetaMask for user authentication & contract execution and JSON-based storage for smart contract interactions.

III. SYSTEM ARCHITECTURE

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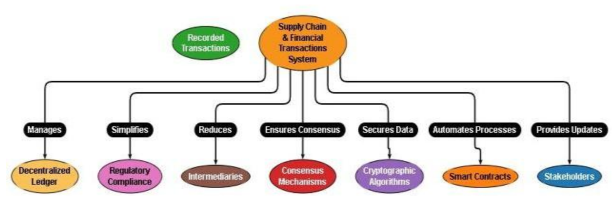

3.1 MAIN SYSTEM:

Supply Chain & Financial Transactions System: This system leverages blockchain technology to improve supply chain management and financial transactions.

KEY FUNCTIONALITIES AND THEIR EFFECTS:

1. Manages → Decentralized Ledger
The system manages a decentralized ledger, ensuring a single source of truth for all transactions. This eliminates data silos and prevents manipulation.

2. Simplifies → Regulatory Compliance
Blockchain's immutable records simplify compliance with laws and auditing requirements.

3. Reduces → Intermediaries
Traditional supply chains and financial systems rely on middlemen (banks, brokers, etc.). Blockchain removes intermediaries, lowering costs.

4. Ensures Consensus → Consensus Mechanisms
Blockchain relies on consensus mechanisms (e.g., Proof of Work, Proof of Stake) to validate transactions. This ensures that there is no fraud or data manipulation.

5. Secures Data → Cryptographic Algorithms
Advanced cryptographic algorithms protect transaction data. Ensures data integrity, security, and confidentiality.

6. Automates Processes → Smart Contracts
Smart contracts automatically trigger when conditions are met. This reduces human intervention, errors, and delays.

7. Provides Updates → Stakeholders
The system offers real-time updates to all stakeholders (producers, distributors, retailers, etc.). This improves decision-making and transparency.

8. Recorded Transactions
The system records all the transactions on blockchain. Which ensures traceability, accountability and prevent fraud.

3.2 ALGORITHMS:

Our paper leverages several core algorithms to ensure security, and transparency. These algorithms are applied across key functionalities such as consensus mechanisms, cryptographic security and smart contract execution. The primary algorithms include:

i. **Practical Byzantine Fault Tolerance (PBFT):** PBFT is a consensus mechanism used in permissioned blockchains. It is designed to withstand malicious nodes and ensure system reliability in the presence of faults.

ii. **SHA-256 (Hashing Algorithm):** Generates a unique hash for every transaction, ensuring immutability. Any change in the data completely alters the hash, preventing tampering.

iii. **Elliptic Curve Cryptography (ECC)**
It is a Public-Key cryptography which is used for secure transactions and digital signatures. Faster than traditional RSA encryption with shorter key lengths.

iv. **Advanced Encryption Standard (AES):** It is a Symmetric Encryption algorithm which encrypts transactions and private data. Ensures confidentiality while allowing authorized decryption.

v. **Digital Signature Algorithm (DSA):** Verifies the authenticity of supply chain records. It prevents forgery by ensuring that transactions are signed with private keys.

3.3 FRAMEWORKS AND TECHNOLOGIES

i. **BLOCKCHAIN:** Hardhat is a blockchain development framework for building, testing, and deploying Ethereum smart contracts**.** It provides a local Ethereum network**,** advanced debugging tools, and automation features, making it ideal for Web3 development**.** Hardhat integrates with libraries like Ethers.js**,** supports Solidity and optimizes smart contract workflows for efficiency and security in blockchain applications.

ii. **SMART CONTRACTS:** Smart contracts are self-executing programs stored on a blockchain, automatically enforcing agreements without intermediaries. Written in Solidity, Ethereum's primary contract language, they enable secure, transparent, and tamper-proof transactions**.** Automating payment processes upon the successful delivery of goods. o Enforcing compliance with supply chain regulations.

iii. **METAMASK**
MetaMask is a cryptocurrency wallet and gateway to blockchain applications, enabling users to manage Ethereum-based assets and interact with decentralized applications (DApps)**.** It supports private key management**,** smart contract interactions and secure transactions. MetaMask also integrates with Web3 libraries, facilitating seamless blockchain connectivity for users and developers.

iv. **WEB DEVELOPMENT FRAMEWORKS**
Two major frameworks are used to build user interfaces (UI) and backend systems for interacting with the blockchain.
Flask/Django: Python-based web frameworks for backend development.
ReactJS: A JavaScript library for creating dynamic and responsive web interfaces.
These are used in developing dashboards for monitoring supply chain activities also enabling user interaction with blockchain features like transactions and reports.

IV. IMPLEMENTATION

KEY FACTORS

i. **Blockchain Network (Central Component)--**
Our Blockchain network is deployed using Hardhat for local testing and MetaMask for interacting with the contracts. It follows a supply chain model, where entities such as producers, distributors, and retailers interact via smart contracts. The blockchain ensures transparency, security, and immutability of transactions.

ii. **External Entities (Users/Stakeholders)--**
   a) Supplier: Uploads goods data to the blockchain.

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b) Manufacturer: Updates inventory records.
c) Distributor: Tracks shipments in real-time.
d) Retailer: Verifies order details and authenticity.
e) Customer: Checks product authenticity via blockchain records.
f) Financial Institution: Processes payments securely on blockchain

iii. **Smart contracts--**
Written in Solidity these smart contracts automate processes such as order verification, inventory updates, and payments:
[1]SupplyChainLifecycle.sol manages the overall supply chain flow, **[2]Producer.sol** manages product creation and registration, **[3]Distributor.sol** handles distributor transactions, **[4]Retailer.sol** oversees retail operations and [5]**Users.sol** Manages user registration and authentication.

V. WORKING

i. The producer (can be any manufacturer) initiates the supply chain process by creating a product and registering it on the blockchain network. This involves recording essential product details such as batch number, production date, origin, and quantity. The system, deployed on Hardhat, ensures that each product entry is cryptographically secured using SHA-256 hashing, preventing data tampering. Once recorded, the information becomes immutable and accessible to all authorized supply chain participants. Producer then initiates the payment to the distributer which is done seamlessly without any middle work as the smart contact for the payment gets executed immediately upon the producer's action.

ii. After production, the distributor takes in the goods and updates their status on the blockchain. This update could include details like shipment time, storage conditions, transit route, and expected delivery dates. Smart contracts ensure automated verification of product authenticity before approving shipment. The use of Practical Byzantine Fault Tolerance (PBFT) consensus guarantees trust in recorded transactions, even if some network nodes fail.

iii. Once the distributor delivers the goods, the retailer verifies and purchases the product via an on-chain transaction, ensuring real-time inventory updates. The system automatically logs ownership transfers using Ethereum-based smart contracts, ensuring that retailers can only sell verified and traceable products.

iv. Retailers, distributors, and other participants use MetaMask to interact with the blockchain system. MetaMask acts as a bridge between the user interface and the Ethereum blockchain, enabling secure digital signatures for transactions and data entries. Every recorded update requires user authentication via public-private key cryptography (ECC) ensuring that only authorized stakeholders can modify the data.

v. Every transaction whether it's product creation, status updates, payments, or transfers, undergoes Ethereum network validation. The blockchain enforces consensus through PBFT, ensuring that all verified data remains immutable and tamper-proof. The network uses SHA-256 hashing to secure transactions, AES encryption for private data, and DSA (Digital Signature Algorithm) to authenticate participants. This final step ensures that supply chain records are transparent, fraud-resistant, and accessible for auditing.

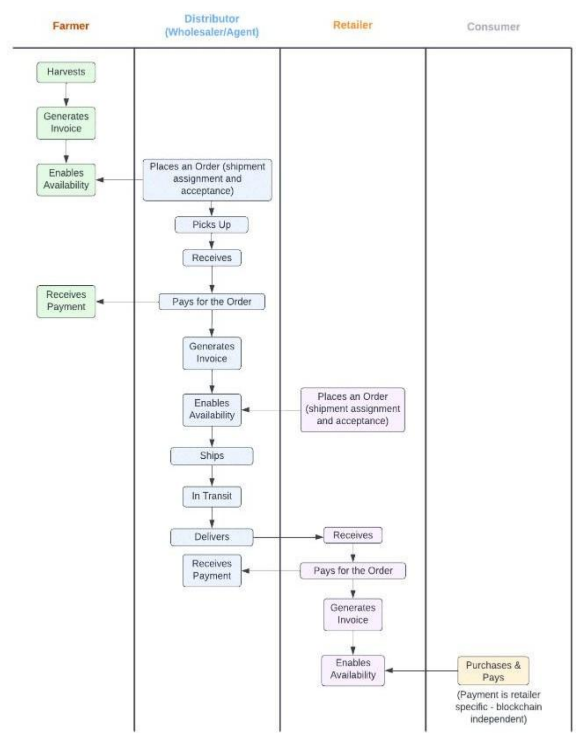

FIG: SUPPLY CHAIN WORKFLOW

VI. RESULTS

Our blockchain-based platform supply chain management has proven to be highly robust across functional, security,

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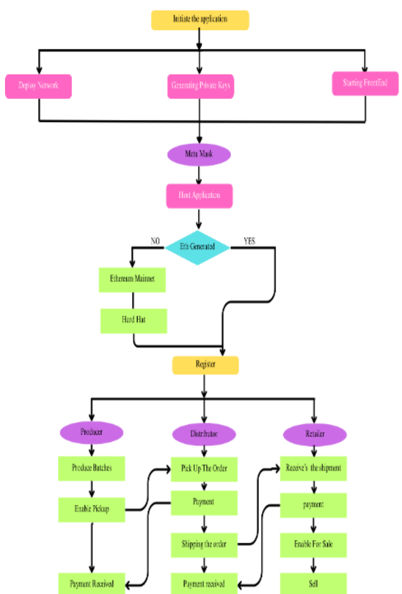
performance and blockchain-specific dimensions. Records valid user authentication with accurate registration and login processes, while incorrect credential attempts triggered as error messages. The system efficiently recorded supply chain transactions on the blockchain, ensuring data immutability, as confirmed by queries returning consistent and unaltered transaction details. Smart contracts automated payments upon delivery confirmation and seamless integration with external payment gateways ensured accurate transaction processing.

Compliance testing verified that the system adheres to GDPR regulations, enabling user data to be anonymized or deleted upon request. Furthermore, API response times for transaction queries met expected latency standards, ensuring real-time data retrieval. Overall, our platform demonstrated really good reliability, security, and efficiency, positioning it as a strong and viable solution for blockchain-based supply chain management.

FIG: REPRESENTATIONAL VIEW



VII. CONCLUSION

In this paper we showcased how we successfully developed a blockchain-based platform for secure supply chain information sharing and financial transactions. By integrating Ethereum for monetary flows and leveraging smart contracts, our system enhances transparency, security, and operational efficiency. This platform addresses the limitations of traditional systems, creating a more resilient and adaptable supply chain network. We hope our approach sets a benchmark for future innovations in supply chain management.

VIII. FUTURE SCOPE

Our project can have further improvements and include various new ideas and technologies implemented into the core model extending its efficiency. Some of them include:

i. *Enhanced Financing & Payment Mechanisms using Stablecoin Payments such as USDC, DAI, or CBDCs for stable transactions instead of ETH.*
ii. *Layer 2 Scaling i.e., using rollups (Optimistic/ZK-rollups) to reduce transaction fees.*
iii. *AI-Powered Supply Chain Optimization such as Predictive Analytics and Anomaly Detection using AI/ML.*

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