

SYNCRO: Web app for managing pharma supply chain using Blockchain

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Computer Science and Engineering
by

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Roshan Kumar Sinha (40111080)** and **Harshit Tathagat (40110446)** who carried out the Project work entitled **"SYNCRO: Web app for managing pharma supply chain using Blockchain"** under my supervision from November 2023 to April 2024.

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ABSTRACT

Our life is full of products that make our lives easier. Manufactured goods are a vital part of these. After the industrial revolution, the usage of manufactured products has drastically increased due to better quality and increase in production quantity. This process of production and distribution led to the creation of a term in the world of management called supply chain. The creation of a finished good requires various processes. All these logistical processes combined together are called the supply chain.

It involves sourcing the raw materials, converting them into finished products, transporting and distributing them among various wholesalers and retailers, and delivering the product to the end consumer. Management of this entire process is a tedious job and can often become complicated as there are too many players and processes involved. Also, there is a high risk of data inconsistency and information mismanagement between two parties. Moreover, in the traditional system, the consumer has no idea about the origins of the product. So, we have created a blockchain-based system that acts as a single source of truth, for the consumer and the members in the supply chain.

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CHAPTER 1

INTRODUCTION

In recent years, the healthcare industry has been confronted with unprecedented challenges, further underscored by the global health crisis. One of the critical areas where these challenges have become glaringly evident is in the supply chain management of medical resources and equipment. The intricacies of procuring, distributing, and tracking vital medical supplies, including pharmaceuticals, medical devices, and personal protective equipment (PPE), have highlighted the need for a robust and innovative solution. Enter blockchain technology, and more specifically, the Ethereum blockchain, which promises to revolutionize the healthcare supply chain landscape.

Traditional healthcare supply chain systems often suffer from a multitude of issues, ranging from counterfeit drugs and medical equipment, inefficient inventory management, opaque transaction records, to regulatory compliance challenges. These shortcomings not only threaten patient safety but also have significant financial implications for healthcare providers. The adoption of Ethereum blockchain in medical supply chain management holds tremendous potential for addressing these issues comprehensively, while also delivering an array of additional benefits.

This project embarks on a comprehensive exploration of how Ethereum blockchain technology is poised to transform the landscape of medical supply chain management. We delve into the fundamental features and advantages that the Ethereum blockchain offers, such as transparency, traceability, immutability, and smart contracts, and examine how these capabilities can be harnessed to significantly enhance the efficiency, security, and reliability of the medical supply chain. Furthermore, we will closely examine real-world use cases and initiatives that are already gaining momentum in their efforts to leverage the Ethereum blockchain for streamlining medical supply chain operations.

The ultimate aim of this exploration is to provide a clear understanding of how the Ethereum blockchain is set to make a paradigm shift in the pharmaceutical industry's approach to supply chain management. By the end of this report, readers will not only grasp the transformative potential of the Ethereum blockchain but also appreciate how its integration can lead to the provision of better patient care, heightened operational performance, and a more resilient healthcare ecosystem, especially in the face of unforeseen challenges like pandemics and global supply chain disruptions.

1.1 BLOCKCHAIN: Transforming Industries with Distributed Ledger Technology

In the digital age, blockchain technology has emerged as a groundbreaking innovation with the potential to transform various industries. Blockchain, at its core, is a distributed ledger technology that offers a secure, transparent, and immutable way to record and verify transactions. Unlike traditional centralized systems, where data is stored in a single location and controlled by a central authority, blockchain operates on a decentralized network, where multiple participants collectively maintain and validate the ledger.

The fundamental principles of blockchain include:

1.1.1 Decentralization: A blockchain network is distributed across a vast number of nodes (computers) worldwide. Each node holds a copy of the entire blockchain, and there is no central authority governing the system. This decentralization reduces the risk of a single point of failure, making it highly resilient.

1.1.2 Transparency: All transactions recorded on the blockchain are visible to all participants in the network. This transparency fosters trust among users as they can independently verify the authenticity and integrity of transactions without relying on intermediaries.

1.1.3 Immutability: Once data is added to the blockchain, it becomes extremely difficult to alter or delete. Each block in the chain contains a cryptographic reference to the previous block, creating a secure and unbreakable link. This immutability ensures the integrity of historical records.

1.1.4 Security: Blockchain employs advanced cryptographic techniques to secure data and control access. Transactions are verified through consensus mechanisms, such as proof of work (PoW) or proof of stake (PoS), making it highly resistant to fraud and hacking attempts.

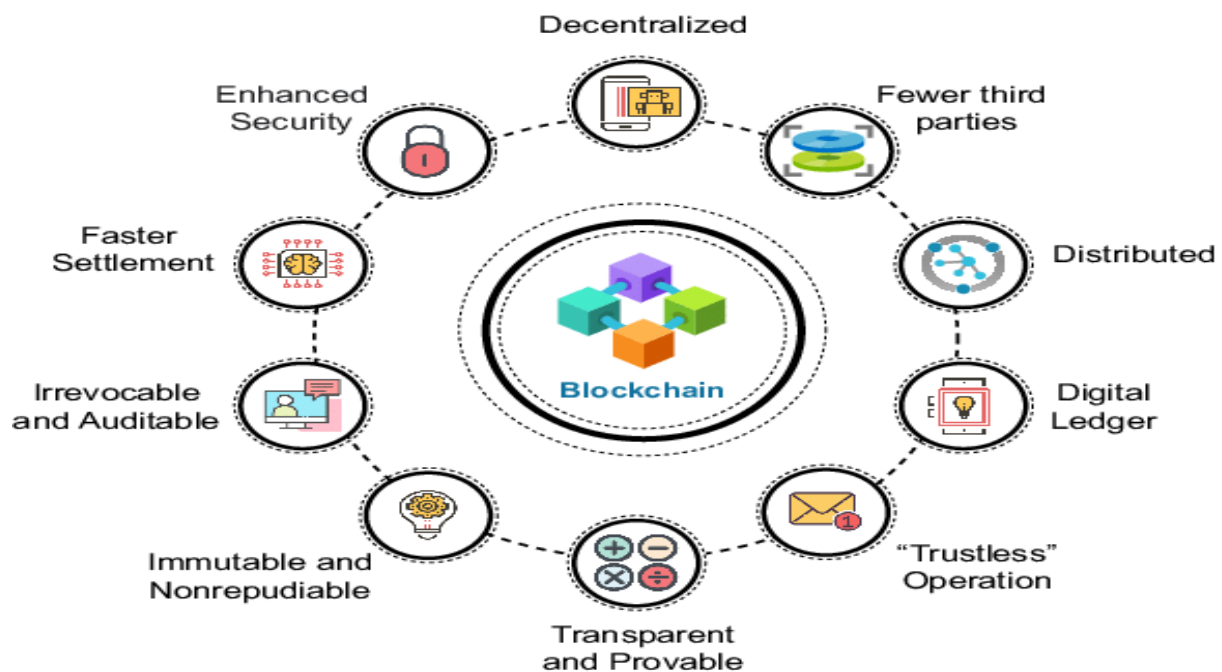


Fig: 1.1: Features of Blockchain Technology

Fig: 1.1. highlights the various features of blockchain technology that are used in numerous areas across the industry in different ways.

1.2 Applications of Blockchain

In finance, blockchain has the potential to revolutionize payments, cross-border transactions, and the issuance of digital assets like cryptocurrencies. It can enhance security, reduce fraud, and streamline settlement processes. Blockchain improves transparency and traceability in supply chains, helping to combat counterfeit products, enhance inventory management, and reduce delays by providing real-time visibility into the movement of goods. Electronic health records (EHRs) can be securely stored on a blockchain, allowing for easy and secure sharing of patient data among healthcare providers while maintaining patient privacy. These self-executing

contracts automate and enforce the terms of agreements without the need for intermediaries. They have applications in legal, insurance, and real estate industries, among others.

Blockchain can enhance the integrity of voting systems by providing secure and transparent methods for casting and counting votes, reducing the risk of election fraud. Blockchain facilitates the creation of transparent energy markets, enabling peer-to-peer energy trading and carbon credit tracking. Artists and content creators can use blockchain to manage rights, royalties, and intellectual property, ensuring fair compensation for their work. Some blockchain networks are used for decentralized governance, allowing participants to collectively make decisions and changes to the protocol. Blockchain enables users to have greater control over their personal data. Instead of entrusting data to centralized entities, individuals can choose to share specific information securely and selectively, reducing the risk of data breaches.

It facilitates faster and cheaper cross-border payments, potentially disrupting the traditional correspondent banking system. This has significant implications for international commerce and remittances. Blockchain-based identity systems offer a secure and portable way for individuals to prove their identity, which can be particularly valuable for accessing services and financial products online. Through blockchain, physical assets such as real estate, art, and even company shares can be "tokenized," representing ownership digitally. This can unlock liquidity, increase accessibility to investments, and streamline the process of asset transfer.

Non-fungible tokens (NFTs) are a type of blockchain-based digital asset used for representing ownership of unique items, such as art, music, or virtual real estate. NFTs have gained immense popularity in the world of digital art and entertainment. Efforts are underway to create blockchain networks that can communicate and transact with each other seamlessly. Interoperability can enhance the utility of blockchain by allowing different networks to work together, similar to how the internet connects various websites.

DeFi platforms leverage blockchain technology to create open and permissionless financial services, including lending, borrowing, trading, and yield farming, without the need for traditional banks or intermediaries. Traditional financial instruments,

such as stocks and bonds, can be issued and traded on blockchain platforms, making the process more efficient and transparent. Blockchain can be used to create secure and tamper-proof voting systems, ensuring the integrity of elections and referendums. Content creators and inventors can timestamp their work on the blockchain to establish proof of ownership and originality, reducing the risk of plagiarism and intellectual property disputes.

In industries like auditing and compliance, blockchain provides a transparent and auditable trail of transactions, reducing the risk of fraud and simplifying regulatory reporting. Blockchain can be used to securely store and verify educational credentials, professional certifications, and employment history, streamlining the hiring process and reducing resume fraud. Some blockchain projects are exploring more eco-friendly consensus mechanisms to address concerns about energy consumption, aligning blockchain technology with sustainability goals.

Blockchain technology continues to evolve rapidly, and its applications are expanding into new domains. As it matures, it holds the potential to revolutionize not just individual industries but also the way society manages and shares data, assets, and trust. However, it's important to note that while blockchain offers numerous advantages, it also faces technical, regulatory, and adoption challenges that must be addressed as it becomes more integrated into various sectors of the economy and society. While challenges such as scalability, energy consumption, and regulatory concerns remain, the growing interest and investment in blockchain suggest that it will continue to play a significant role in shaping the future of various industries.

1.3 Types of Blockchains

Blockchain technology has evolved, leading to the development of various types of blockchains, each tailored to specific use cases and requirements. The main types of blockchains include:

1.3.1 Public Blockchains

Public blockchains are open to anyone and do not require permission to participate. They are decentralized and maintained by a distributed network of nodes. Bitcoin and Ethereum are examples of permissionless public blockchains.

1.3.2 Private Blockchains

Private blockchains restrict access to a select group of participants. These networks are often used within organizations or consortiums for specific business applications, such as supply chain management. Permissioned blockchains offer more control and privacy.

1.3.3 Consortium Blockchains

Consortium blockchains are governed by a group of organizations rather than a single entity. While they maintain some level of decentralization, access to the network is restricted to a predefined set of participants. Consortium blockchains strike a balance between public and private blockchains and are commonly used in industry-specific consortia.

1.3.4 Hybrid Blockchains

Hybrid blockchains integrate elements of both public and private blockchains. They allow for public accessibility and transparency while also offering restricted areas for private transactions or confidential data. This approach is suitable for applications requiring a combination of transparency and privacy.

1.3.5 Permissioned Public Blockchains

Permissioned public blockchains, also known as semi-public blockchains, allow anyone to participate in the network but require participants to meet specific criteria or obtain permission for certain activities. These blockchains aim to strike a balance between openness and control.

1.3.6 Sidechains

Sidechains are separate blockchain networks that can be connected to a main blockchain (often referred to as the mainchain). They enable the execution of smart contracts and the transfer of assets while preserving the mainchain's security and scalability. Sidechains are often used to alleviate congestion on the mainchain and enable specific functions or applications.

1.3.7 Multi-Chain Networks

Multi-chain networks consist of multiple blockchains that can communicate and share data or assets seamlessly. They promote interoperability and can be used for diverse purposes within a single ecosystem.

1.3.8 Permissioned Proof of Authority (PoA) Blockchains

In PoA blockchains, a limited number of trusted validators are responsible for validating transactions. These networks prioritize efficiency and can be found in enterprise settings where trust among participants is established.

1.3.9 Permissioned Proof of Stake (PoS) Blockchains

PoS blockchains select validators based on the amount of cryptocurrency they hold and are willing to "stake" as collateral. These networks are more energy-efficient compared to PoW (Proof of Work) blockchains like Bitcoin.

1.3.10 Directed Acyclic Graphs (DAGs)

While not traditional blockchains, DAGs are a different approach to distributed ledger technology. They use a non-linear structure to achieve consensus and process transactions. IOTA and Nano are examples of blockchain alternatives using DAGs.

The choice of blockchain type depends on the specific use case, requirements for decentralization, privacy, scalability, and the intended user base. Different industries and applications may benefit from different blockchain architectures, and some may even use multiple types in tandem to optimize functionality and efficiency.

1.4 Popular Blockchains

Several popular and well-known blockchains have gained prominence across various use cases and industries. Here are some of the popular blockchains:

1.4.1 Bitcoin (BTC)

Bitcoin is the original and most well-known cryptocurrency. It operates on a permissionless, public blockchain and is primarily used as a digital store of value and a medium of exchange.

1.4.2 Ethereum (ETH)

Ethereum is a versatile blockchain platform known for its smart contract capabilities. It allows developers to build decentralized applications (DApps) and has been at the

forefront of the decentralized finance (DeFi) and non-fungible token (NFT) movements.

1.4.3 Binance Smart Chain (BSC)

Binance Smart Chain is a blockchain platform that has gained popularity for its high speed and low transaction fees. It is often used for DeFi applications and has strong integration with the Binance cryptocurrency exchange.

1.4.4 Cardano (ADA)

Cardano is known for its focus on scalability, sustainability, and interoperability. It aims to provide a secure and scalable platform for the development of DApps and smart contracts.

1.4.5 Polkadot (DOT)

Polkadot is designed to enable the interoperability of multiple blockchains. It operates as a heterogeneous multi-chain network, allowing different blockchains to communicate and share information.

1.4.6 Solana (SOL)

Solana is a high-performance blockchain known for its fast transaction processing and scalability. It has gained popularity for DeFi and NFT projects due to its low transaction costs.

These are just a few examples of popular blockchains, and there are many more emerging and specialized blockchains catering to specific use cases and industries.

1.5 Blockchain in Supply Chain

Blockchain technology has demonstrated significant potential to revolutionize supply chain management across various industries. It offers transparency, traceability, security, and efficiency that can address many of the longstanding challenges in supply chain operations. Here are some key ways blockchain is impacting supply chain management:

It provides an immutable ledger where all transactions and events in the supply chain are recorded. This transparency enables all authorized participants to track the

movement and status of goods from their origin to their destination in real time. This helps reduce the opacity and potential for fraud within the supply chain. With blockchain, it becomes much easier to verify the authenticity and provenance of products. In industries like food and pharmaceuticals, this can be critical for ensuring consumer safety and compliance with regulations. Consumers can scan a QR code on a product and instantly access detailed information about its journey. Blockchain's immutable records make it difficult for counterfeit goods to enter the supply chain undetected. Companies can use blockchain to certify the authenticity of products and prevent counterfeit items from reaching consumers.

Blockchain can streamline inventory management by providing a real-time view of inventory levels, location, and status. This reduces overstocking, understocking, and the need for manual tracking, saving costs and improving efficiency. Smart contracts are self-executing contracts with predefined rules and conditions. They can automate various supply chain processes, such as payments, order fulfilment, and compliance checks, reducing the need for intermediaries and minimizing errors. In international trade, blockchain can significantly speed up the settlement of transactions. Traditional cross-border transactions can take days or even weeks, but blockchain can facilitate near-instant settlement, reducing the time and costs associated with cross-border payments.

It enables more accessible and efficient supply chain financing solutions by providing a transparent and auditable record of transactions. This can benefit suppliers by improving cash flow and reducing financing costs. For industries subject to strict regulatory requirements, such as pharmaceuticals and healthcare, blockchain can help ensure compliance by providing an immutable audit trail of all activities. The encryption and consensus mechanisms make it highly secure. This ensures the confidentiality and integrity of sensitive supply chain data, protecting it from tampering or unauthorized access. Participants in the supply chain can receive real-time alerts and notifications about critical events, such as delays, temperature deviations (important for perishable goods), or quality issues. This allows for proactive problem-solving and risk mitigation.

It can be used to track the environmental impact of products throughout their lifecycle, helping companies make more sustainable supply chain decisions.

Blockchain's decentralized nature means that there is no single point of control or failure in the supply chain, enhancing its resilience and reliability.

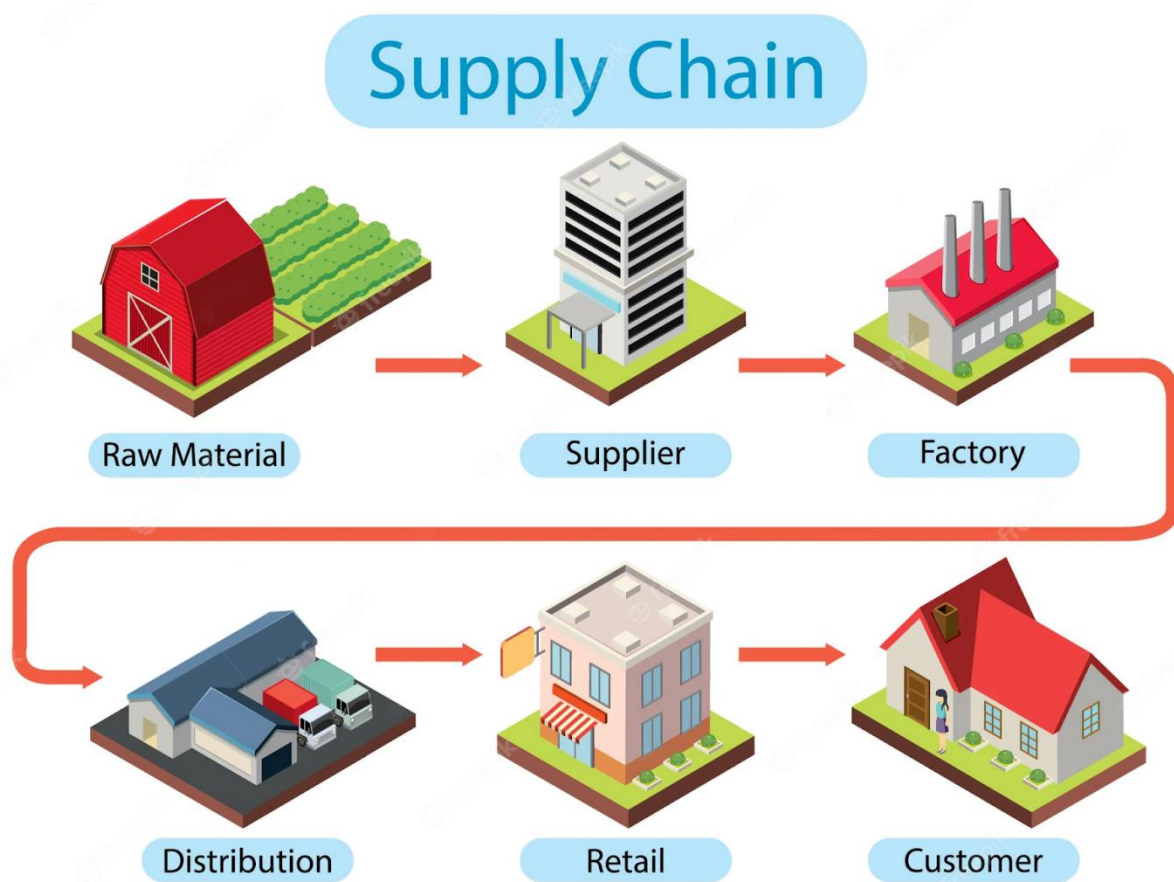


Fig: 1.2: Stages in a Supply Chain

Fig: 1.2. represents the various stages a product goes through in a supply chain before reaching the consumer.

1.6 Objectives

This study aims to enforce real-time visibility, enhanced tracking, and tracing of products and transactions in the supply chain. The improvement in traceability especially immutable and auditable records of supply chain movements as well as identifying product origin, authenticity, and quality are of key interest. We strive to enhance collaboration and trust through peer-to-peer interaction between stakeholders. Finally streamlining processes, increasing efficiency using automation and reduction in manual errors along with increased operational efficiency and cost savings can be achieved.

CHAPTER 2

LITERATURE SURVEY

Supply chain management has been extensively studied since the inception of blockchain technology, as it solves a fundamental and widespread issue in the global markets. This survey contains the survey of the recent work of researchers from around the world and their findings.

Saroj Kumar Nanda [1] et. al. focus on the development of a novel technique of Healthcare Supply Chain Management (HSCM). Focusing on the adoption of new technologies to incorporate into the pre-existing blockchain-based systems leads to its improvement. It proposes a novel idea of integrating IoT-based sensors such as RFID tags for scanning and real-time detection of products at each stage and using a bi-objective mathematical model with the goals of minimizing destination costs and reducing the number of damaged items during public transport. The work of Davor Dujak and Domagoj Sajter [13] lays the theoretical foundations of blockchain-based technologies and highlights the importance of traceability and visibility, the benefits of IoT and RFID technology, and how blockchain verifies data collected from IoT devices, with concrete examples and real-life implementations and companies in food and consumer goods industry. It also illuminated the various facets of supply chain industries and their inner working like demand forecasting, open access, fraud prevention, and transaction automatization.

Maher A.N. Agi [4] et. al. work introduces a new approach to Decision-Making Trail and Evaluation Laboratory (DEMATEL). This method helps extract insights and logic from data collected from 37 experts in France. These experts provide input on the impact of the identified enablers and their interdependencies. It also analyses the pressure points that are particularly influential in the adoption of blockchain technology in the supply chain. The paper describes the methodology used to analyse the influence of various enablers on blockchain adoption in the supply chain.

The paper of Rita Azzi [12] et.al. discusses the integration of blockchain technology into supply chain management to enhance reliability, transparency, authenticity, and security within the supply chain. The paper acknowledges that traditional centralized supply chain management systems may expose the supply chain to issues such as

corruption, fraud, and tampering, highlighting the need for a more robust and secure solution. It underlines the components used in tracking systems such as tags, tracers, QR codes, RFID sensors, etc., along with their associated challenges and the vulnerabilities associated with centralized systems. It describes real-life cases such as the Modum and Ambrosus startups who have developed a system that merges IoT, blockchain technology, and real-time sensors to trace and transmit products' information during the whole manufacturing process. Blockchain technology plays a significant role in pharmaceutical traceability, as demonstrated by a noteworthy study by Smith and Johnson that emphasizes how the technology may provide an irreversible record of every drug's path from manufacturing to distribution. As a result, worries about illegal diversions and fake medications are allayed, guaranteeing the integrity and authenticity of pharmaceutical products. [5]

An automated way to automate and enforce agreements in the pharmaceutical supply chain is through the use of smart contracts, a fundamental component of blockchain technology. Case studies that demonstrate how smart contracts improve transactional efficiency among stakeholders, decrease fraud, and streamline procedures are examined in research by Brown and Garcia. [6] In a study, Chen and Kim [9] look into the cost and efficiency savings that blockchain technology can provide pharmaceutical supply chains. The study examines how supply chain efficiency is affected by blockchain technology, highlighting the areas in which these technologies work best to cut costs and improve operational effectiveness.

The work of Davor Dujak and Domagoj Sajter lays the theoretical foundations of blockchain-based technologies and highlights the importance of traceability and visibility, the benefits of IoT and RFID technology, and how blockchain verifies data collected from IoT devices, with concrete examples and real-life implementations and companies in food and consumer goods industry. It also illuminated the various facets of supply chain industries and their inner working like demand forecasting, open access, fraud prevention, and transaction automatization. [13] Sohail Jabbar [10] et.al. address the drawbacks of the existing supply chain system, analyse the consensus mechanism and introduce a new model called the MOHBSCchain model. This model likely represents a conceptual framework or solution to some of the challenges identified in the analysis, aiming to facilitate the integration of blockchain technology in supply chain management. It thoroughly discusses the technical as

well as the non-technical aspects of blockchain technology. Some of the major non-technical include the lack of understanding, waiting for wider adoption, market acceptability, skill gap, data correctness, etc. Also, some of the pressing technical issues arise from the centralized and distributed architectures along with some primitive issues of the blockchain like scalability and interoperability.

It highlights some prospective areas of research in the blockchain domain:

- Built-in analytics
- Integration and Analysis Across On-chain and Off-chain data
- Development of Smart Contract templates
- Security analysis for Smart Contracts
- Standardization and Automation of Governance
- Query Execution system for encrypted data
- Incorporation of Right-to-Forget mechanism

Xi Xia Niu and Zeping Li [11] combined research on the blockchain network on supply chain management based on blockchain showcases the structure and features of the blockchain but mainly highlights the problems associated with it such as delay in information transfer, lack of transparency, and weak traceability and how the blockchain is applied to the supply chain. Francesco Longo [14] et. al. develop a theoretical supply chain model that replicates supply chain operations. This model integrates with the blockchain with the software connector, enabling scenario-based statistical analysis, using an Ethereum-like blockchain, and provides the necessary implementation ideas for the same.

2.1 Open Problems in the Existing System

- Problems with existing traceability systems
- Centralized vs Distributed architectures
- IoT and Centralized Cloud Infrastructures
- Data fragmentation
- Lack of understanding and wide-scale adoption
- Scalability
- Interoperability

CHAPTER 3

REQUIREMENT ANALYSIS

3.1 Software Requirements

- **Ethereum:** Ethereum is a decentralized blockchain platform that establishes a peer-to-peer network that securely executes and verifies application code, called smart contracts. Smart contracts allow participants to transact with each other without a trusted central authority.
- **Remix IDE:** Remix Online IDE is a powerful toolset for developing, deploying, debugging, and testing Ethereum and EVM-compatible smart contracts.
- **MetaMask wallet:** MetaMask is a software cryptocurrency wallet used to interact with the Ethereum blockchain. It allows users to access their Ethereum wallet through a browser extension or mobile app, which can then be used to interact with decentralized applications.
- **Infura/Alchemy:** Infura is a world-class node provider that gives us access to RPC endpoints. These endpoints, in turn, enable you to connect with major blockchain and L2 networks available in the market today, see [here](#) for a full list. Together with Truffle, Infura makes it extremely simple to connect to a particular chain.
- **MySQL database:** MySQL is a relational database management system. A relational database stores data in separate tables rather than putting all the data in one big storeroom. The database structure is organized into physical files optimized for speed.
- **Hardhat/Truffle:** Hardhat is a development environment that can help ease the development process of Ethereum-based Web3 applications. It can help with everything from compiling, testing, deploying, and debugging Ethereum software. Also, you can verify a smart contract with Hardhat, which is highly beneficial.
- **Ganache:** Ganache is a local development blockchain used to develop decentralized applications on the Ethereum blockchain. It simulates the

Ethereum network, and you can see how your DApp will perform before you release it to production.

- **HTML:** HTML stands for Hyper Text Markup Language. HTML is the standard markup language for creating Web pages. HTML describes the structure of a Web page. HTML consists of a series of elements. HTML elements tell the browser how to display the content.
- **CSS:** Cascading Style Sheets is a style sheet language used for describing the presentation of a document written in a markup language such as HTML or XML. CSS is a cornerstone technology of the World Wide Web, alongside HTML and JavaScript.
- **JavaScript:** JavaScript, often abbreviated as JS, is a programming language that is one of the core technologies of the World Wide Web, alongside HTML and CSS.

CHAPTER 4

DESCRIPTION OF PROPOSED SYSTEM

4.1 Proposed System

The system consists of a front end, a back end, and various sensors. The front end consists of various user interface devices like computers, and mobile devices. The backend consists of an Ethereum blockchain network. During transport from manufacturer to end-user, in this approach, we use various IoT devices like sensors, activators, and other devices, which are attached to the good and allow the data to be collected from the commodity in real time. These are useful for Shipment tracking, temperature control, carrier identification, rapid delivery, etc. In the case of medicinal drugs, it becomes even more crucial as these are delicate and can easily lose their efficacy if not handled with proper care, and not delivered at the right time.

A Postgres SQL database is used to store the sensitive information of the users in the supply chain as the data stored in the blockchain is inherently public. The smart contract contains the code that allows the user to add, update, and retrieve data from the blocks in the chain. The user cannot interact with the blockchain directly. For this, we have created a web portal for the interaction and an HTTP server for handling user requests. The users can use their phones, laptops, PC, etc. to access the blockchain via the web server. We have used Ganache as the local blockchain environment to test and Infura as the service to deploy the code to a real chain for use.

Even after all this the main question still remains unanswered, what is in this for the consumer and why should we bother to create such an elaborate system? Turns out the answer to this is very straightforward. We as consumers, have no idea where the products have come in from and what are the actual raw materials that go into creating the products. Not only the consumer, but every member associated with the blockchain benefits from this as they all know the source, location, creation time, and other essential details about the product that are often lost in the traditional supply chain system.

4.2 System Architecture

The system architecture includes various modules such as HTTP servers, smart contracts, a SQL database interconnected via an Ethereum blockchain network.

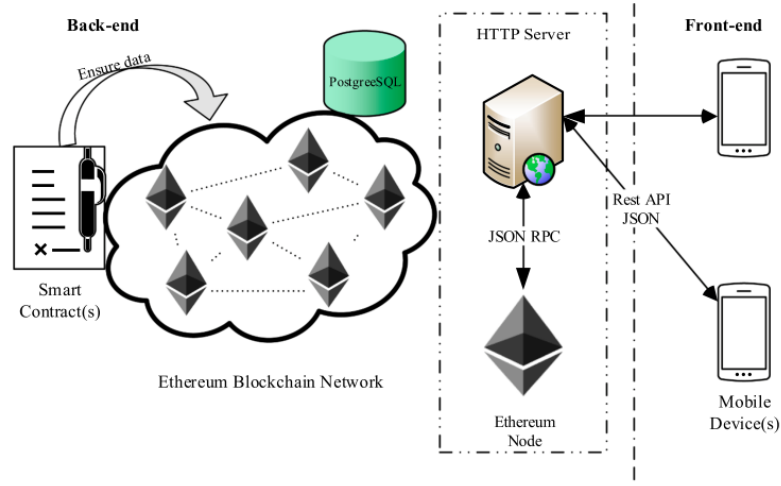


Fig: 4.1: System Architecture

Fig: 4.1 shows the various components that are used in the design of the project and their interrelation.

4.3 Modules

4.3.1 Ethereum blockchain network: It is an open access and data-friendly service to everyone. It is useful for verifying front-end registered data. Smart contracts are running in an Ethereum blockchain virtual machine. In blockchain networks, smart contracts are used to verify the data.

4.3.2 Smart contracts: These define different operations that allow access control systems. The end users interrelate with the smart contract system by using the REST API and JSON.

4.3.3 HTTP Server: A HyperText Transfer Protocol (HTTP) server is used to process various requests, and exchange information on the World Wide Web (WWW). This approach provides the interface between the front end and the back end. The key purpose of an HTTP server is to store, process, and deliver web pages to clients.

4.3.4 Database: In this approach, we are using MySQL database for storing sensitive data, and user information.

4.3.5 IoT Devices: In medical logistic IoT devices plays a very crucial role during transport of products between the manufacturer and the end-user. IoT is a network of physical devices or things that are fixed with software, electronic devices, networks, various sensors, QR codes, RFID tags, and barcode systems that are allowed to collect and exchange data.

4.4 Choice of Blockchain

Out of the various stated blockchains, Ethereum stood out with the best capabilities. These are the current capabilities of Enterprise Ethereum:

4.4.1 Data coordination: Ethereum's decentralized architecture better allocates information and trust so that network participants do not have to rely on a central entity to manage the system and mediate transactions.

4.4.2 Rapid deployment: With an all-in-one SaaS platform like Hyperledger Besu, enterprises can easily deploy and manage private blockchain networks instead of coding a blockchain implementation from scratch.

4.4.3 Permissioned networks: The ConsenSys Quorum open-source protocol layer enables businesses to build on public or private Ethereum networks, ensuring your solution fits any potential regulatory and security requirements.

4.4.4 Network size: The main net proves that an Ethereum network can work with hundreds of nodes and millions of users. Most enterprise blockchain competitors are only running networks of less than 10 nodes and have no reference case for a vast and viable network. Network size is critical for enterprise consortia that are bound to outgrow a handful of nodes.

4.4.5 Private transactions: Enterprises can achieve granularity of privacy in Ethereum by forming private consortia with private transaction layers. On ConsenSys Quorum, private information is never broadcast to network participants. Private data is encrypted and only shared directly with relevant parties.

4.4.6 Scalability and performance: With Proof of Authority consensus and custom block time and gas limit, consortium networks built on Ethereum can outperform the public main net and scale up to hundreds of transactions per

second or more depending on network configuration. Protocol-level solutions like sharding and off-chain, layer 2 scaling solutions such as Plasma, and state channels present opportunities for Ethereum to increase its throughput in the near future.

4.4.7 Finality: A blockchain's consensus algorithm secures confidence that the record of transactions remains tamper-proof and canonical. Ethereum offers customizable consensus mechanisms including RAFT and IBFT for different enterprise network instances, ensuring immediate transaction finality and reducing the required infrastructure that the Proof of Work algorithm demands.

4.4.8 Incentive layer: Ethereum's crypto-economic layers allow business networks to develop mechanisms that both punish nefarious activity and create rewards around activities such as verification and availability.

4.5.9 Tokenization: Businesses can tokenize any asset on Ethereum that has been registered in a digital format. By tokenizing assets, organizations can fractionalize previously monolithic assets (real estate), expand their line of products (provably rare art), and unlock new incentive models (crowdsourced data management).

4.4.10 Standards: Ethereum is where the standards are. Protocols around token design (ERC20), human-readable names (ENS), decentralized storage (Swarm), and decentralized messaging (Whisper) keep the ecosystem from balkanizing. For enterprises, the Enterprise Ethereum Alliance's Client Specification 1.0 defines the architectural components for compliant enterprise blockchain implementations. The EEA is planning to release version 2.0 of the spec soon.

4.4.11 Interoperability and open source: Consortia on Ethereum are not locked into the IT environment of a single vendor. Amazon Web Services customers, for example, can operate private networks with Kaleido's Blockchain Business Cloud. Like the Java community's spec-driven philosophy, the Ethereum ecosystem welcomes contributions to the codebase through Ethereum Improvement Proposals (EIPs).

CHAPTER 5

RESULTS AND DISCUSSION

It would be too optimistic to believe that this blockchain-based system is entirely fault-proof and acts as a silver bullet to all supply chain-related issues. We must realize that the blockchain is still a nascent technology and its current implementation and applications are limited. The modules and packages are rapidly being updated hence creating friction for developers and users.

This software created for supply chain management has its flaws, one of which is its intense dependence on the wallet. This piece of software depends on the wallet component to sign the various transactions and deduct and deposit ethers from and to various Ethereum storehouses of the various entities in the supply chain. This wallet dependence also means that an entity cannot register in the supply chain if it does not have a wallet and hence cannot be a part of the supply chain processing.

Another shortcoming is, that we have not created the wallet that is utilized so its invalidity in the future could cause a serious threat to the software. The implementation does not include fail safes for edge cases which might occur in a pragmatic supply chain.

The design assumes a simple linear supply chain and workflow, but in practice, the supply chain of a drug can be far more cumbersome, under such circumstances further improvements and additions need to be done in the source code and design architecture of the system. The room for further improvement is always present and dwelling on improved design strategies, less cohesive modules, the incorporation of artificial intelligence for automated fault rectification, improved user experience and more robust implementation remains open.

5.1 Advantages

Each batch of items is equipped with a tag that effectively monitors the location of the commodities and interactions between supply chain actors, the data is highly reliable and credible. Blockchain maintains the chain of records that covers the information about manufacturers, drug authorities, distributors, and end-users. Blockchain technology does not depend upon third-party people for verifying

products during transfer between the manufacturer and customer. Once information is entered into the blockchain, it's very difficult to alter/damage unauthorized users.

The data owners have no control over/her data, and they do know the information about participants involved in the SC during the transfer of the products. Integrating IoT with Blockchain technology provides real-time information sharing between all parties involved in the transaction. The participants can easily access product information at any time in a transparent manner.

The consensus process in Blockchain is a fault-tolerance method that stops fraudulent nodes from writing erroneous data. Smart contracts, which use data from the blockchain to verify when contractual obligations are completed and when payments can be given, can make functions like invoicing, payments, and physical transportation of products more cost-effective, auditable, and automated. Billing and payment are the most complex and time-consuming transactions, and they can lead to manipulation, fraud, and errors. Blockchain can automate the invoicing and payment process, ensuring accuracy and accurate computations.

5.2 Screenshots

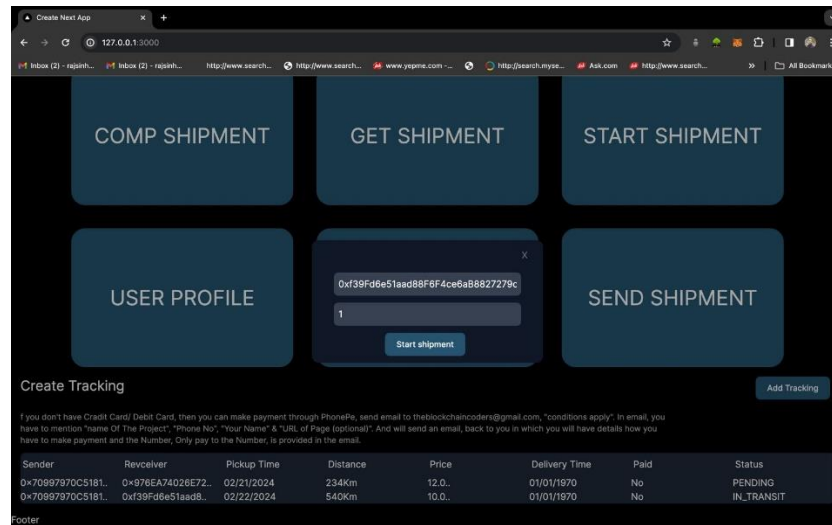


Fig: 5.1: Start Shipment

Fig:5.1 shows the first phase of the drug dispatch, in this step, the receiver is assigned to the dispatch along with an ID to identify it on the blockchain. This step is done by the manufacturer of the drug. It also includes incorporating the details of the drugs that is to be dispatched.

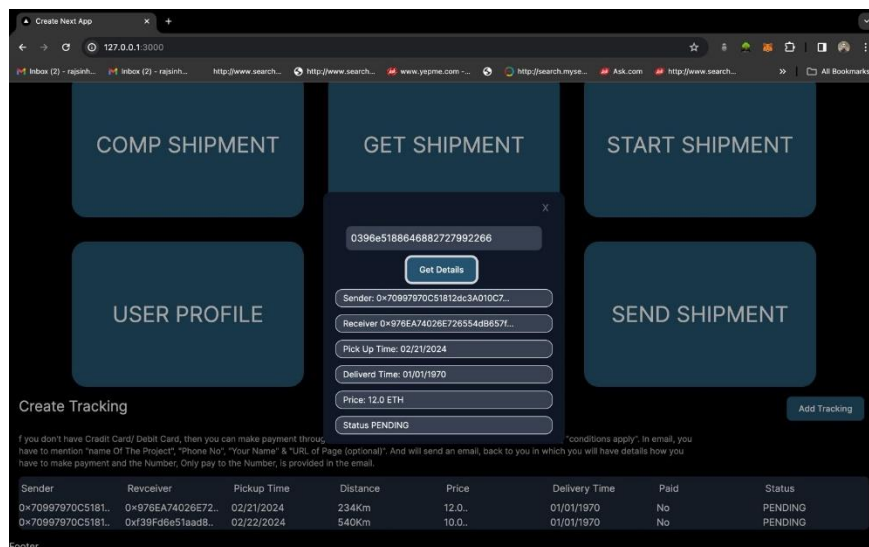


Fig: 5.2: Get Shipment

Fig:5.2 represents the steps which involves getting the information about the sent dispatch by the logged-in entity. It includes the sender, the receiver, the pickup time, the delivery time, the price and the status of the dispatch.

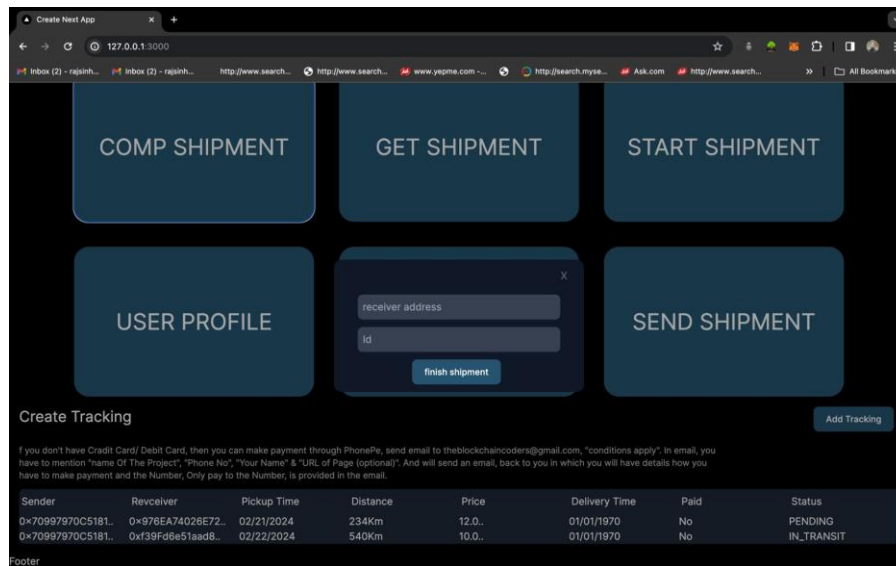


Fig: 5.3: End Shipment

Fig:5.3 shows the end shipment page which takes in the receiver's address and the ID of the dispatch stored in the blockchain to update its status to 'finished'. This is done by the creator of the drug dispatch.

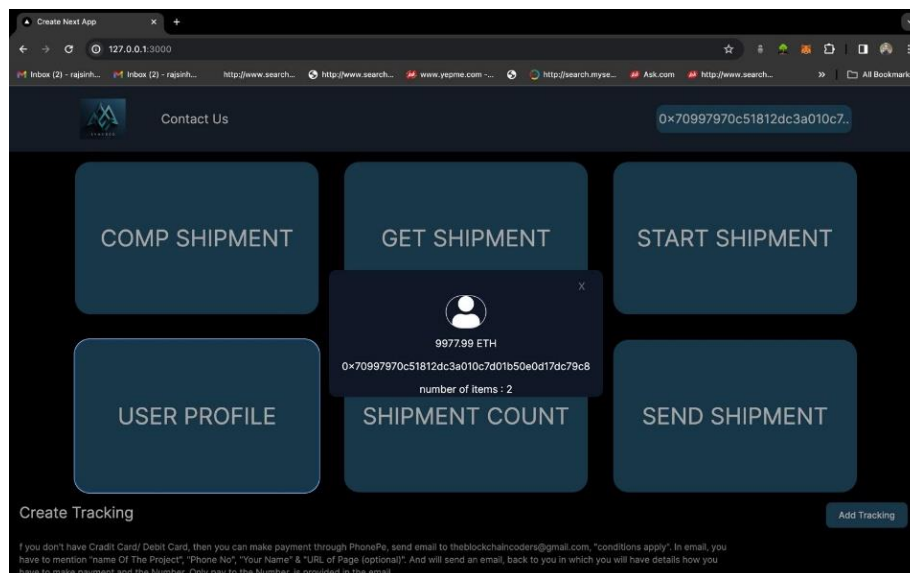


Fig: 5.4: User Profile

Fig:5.4 represents the user profile page that describes the details of the user such as the amount of ethers in his account, the number of items he has shipped and his MetaMask ID.

CHAPTER 6

SUMMARY AND CONCLUSION

In recent years, the healthcare industry has faced acute challenges in supply chain management, especially underscored by the global health crisis. The intricate nature of procuring, distributing, and tracking medical resources necessitates a robust solution. Blockchain, particularly Ethereum, emerges as a transformative technology to address issues like counterfeit drugs, inefficient inventory management, and transparency gaps. This project focuses on leveraging Ethereum blockchain's features – transparency, traceability, immutability, and smart contracts – to enhance medical supply chain efficiency, security, and reliability. Real-world instances showcase the practical ramifications of integrating the Ethereum blockchain into the operational framework of medical supply chains.

The research aims to provide a detailed technical insight into how Ethereum blockchain can revolutionize healthcare supply chain management. By delving into the intricacies of the technology, the study showcases its potential to not only optimize operational processes but also fortify the healthcare system's resilience in the face of unforeseen challenges, such as pandemics and global disruptions.

REFERENCES

- [1] Nanda, S.K., Panda, S.K. & Dash, M. Medical supply chain integrated with blockchain and IoT to track the logistics of medical products. *Multimed Tools Appl* **82**, 32917–32939 (2023).
- [2] Ketki Nirantar, Rishabh Karmakar, Pooja Hiremath, Prof. Deptii Chaudhari; Blockchain-based Supply Chain Management, 3rd International Conference for Emerging Technology (INCET) Belgaum, India. (2022)
- [3] Dr. Chetanpal Singh, Dr. Rahul Thakkar, and Jatinder Warraich; Blockchain in Supply Chain Management, European Journal of Engineering and Technology Research (2022)
- [4] Maher A.N. Agi, Ashish Kumar Jha, Blockchain technology in the supply chain: An integrated theoretical perspective of organizational adoption, International Journal of Production Economics, Volume 247 (2022)
- [5] K. Nirantar, R. Karmakar, P. Hiremath, and D. Chaudhari, “Blockchain based supply chain management,” in 2022 3rd international conference for emerging technology (INCET) (IEEE, 2022) pp. 1–8.
- [6] C. Singh, R. Thakkar, and J. Warraich, “Blockchain in supply chain management,” European Journal of Engineering and Technology Research 7, 60–69 (2022).
- [7] A. Chang, N. El-Rayes, and J. Shi, “Blockchain technology for supply chain management: A comprehensive review,” FinTech 1, 191–205 (2022).
- [8] R. Casado-Vara, A. González Briones, J. Prieto, and J. Corchado Rodríguez, “Smart contract for monitoring and control of logistics activities: Pharmaceutical utilities case study,” (2019) pp. 509–517
- [9] K. Y. Chen L., “Efficiency gains and cost reduction through blockchain in pharmaceutical supply chain,” International Journal of Operations and Production Management 42, 45–63 (2022)
- [10] Jabbar, S., Lloyd, H., Hammoudeh, M. *et al.* Blockchain-enabled supply chain: analysis, challenges, and future directions. *Multimedia Systems* **27**, 787–806 (2021).

- [11] Xiaxia Niu, Zeping Li; Research on Supply Chain Management Based on Blockchain Technology, J. Phys.: Conf. Ser. **1176** 042039 (2019)
- [12] Rita Azzi, Rima Kilany Chamoun, Maria Sokhn, The power of a blockchain-based supply chain, Computers & Industrial Engineering, Volume 135 (2019).
- [13] Dujak, D., Sajter, D. Blockchain Applications in Supply Chain. In: Kawa, A., Maryniak, A. (eds) SMART Supply Network. EcoProduction. Springer, Cham (2019).
- [14] Francesco Longo, Letizia Nicoletti, Antonio Padovano, Gianfranco d'Atri, Marco Forte, Blockchain-enabled supply chain: An experimental study, Computers & Industrial Engineering, Volume 136 (2019).
- [15] Shivani Bhalerao, Siya Agarwal, Shruthi Borkar, Shruti Anekar, Nikita Kulkarni, Sumedha Bhagwat; Supply Chain Management using Blockchain, International Conference on Intelligent Sustainable Systems (2019)
- [16] Si Chen, Rui Shi, Zhuangyu Ren, Jiaqi Yan, Yani Shi, Jinyu Zhang; A Blockchain-based Supply Chain Quality Management Framework, The Fourteenth IEEE International Conference on e-Business Engineering (2017)

APPENDIX

A. SOURCE CODE

Tracking.sol

```
// SPDX-License-Identifier: MIT

pragma solidity ^0.8.0;

contract Tracking {

    enum ShipmentStatus {PENDING,IN_TRANSIT,DELIVERED}

    struct Shipment{

        address sender;

        address receiver;

        uint256 pickupTime;

        uint256 deliverTime;

        uint256 distance;

        uint256 price;

        ShipmentStatus status;

        bool isPaid;

    }

    mapping ( address=>Shipment[]) public shipments;

    uint256 public shipmentCount;
```

```
// for front-end display purpose
```

```
struct TypeShipment{  
    address sender;  
    address receiver;  
    uint256 pickupTime;  
    uint256 deliverTime;  
    uint256 distance;  
    uint256 price;  
    ShipmentStatus status;  
    bool isPaid;  
}
```

```
TypeShipment[] public typeShipments;
```

```
//in event can pass atmost 3 indexed for filtering the data but not more than thant
```

```
event ShipmentCreated(address indexed sender,address indexed receiver,uint256  
pickupTime , uint256 distance,uint256 price);
```

```
event ShipmentInTransist (address indexed sender,address indexed receiver,uint256  
pickupTime);
```

```
event ShipmentDelivered (address indexed sender,address indexed receiver,uint256  
pickupTime);
```

```
event ShipmentPaid (address indexed sender,address indexed receiver,uint256  
amount);
```

```
constructor(){
```

```
    shipmentCount=0;
```

```
}
```

```
function createShipment(address _receiver,uint256 _pickupTime,uint256 _distance,  
uint256 _price)public payable{
```

```
    require(msg.value == _price,"Payment amount must match the price");
```

```
    Shipment memory shipment=Shipment(msg.sender,_receiver,_pickupTime,0,  
    _distance, _price,ShipmentStatus.PENDING,false);
```

```
    shipments[msg.sender].push(shipment);
```

```
    shipmentCount++;
```

```
    typeShipments.push(
```

```
        TypeShipment(
```

```
            msg.sender,
```

```
            _receiver,
```

```
            _pickupTime,
```

```
            0,
```

```
            _distance,
```

```
            _price,
```

```
            ShipmentStatus.PENDING,
```

```
            false
```

```
        )
```

```
    );
```

```

    emit ShipmentCreated(msg.sender,_receiver, _pickupTime, _distance, _price);

}

function startShipment(address _sender,address _receiver ,uint256 _index)public {

    Shipment storage shipment= shipments[_sender][_index];

    TypeShipment storage typeShipment= typeShipments[_index];

    require(shipment.receiver==_receiver,"Invalid receiver");

    require(shipment.status==ShipmentStatus.PENDING,"Shipment already in
transist.");

    shipment.status=ShipmentStatus.IN_TRANSIT;

    typeShipment.status=ShipmentStatus.IN_TRANSIT;

    emit ShipmentInTransist(_sender, _receiver, shipment.pickupTime);

}

function completeShipment(address _sender,address _receiver,uint256 _index)
public {

    Shipment storage shipment= shipments[_sender][_index];

    TypeShipment storage typeShipment= typeShipments[_index];

    require(shipment.receiver==_receiver,"Invalid receiver");

    require(shipment.status==ShipmentStatus.IN_TRANSIT,"Shipment already in
transist.");

    require(!shipment.isPaid,"shipment already paid");

```

```

shipment.status=ShipmentStatus.DELIVERED;

typeShipment.status=ShipmentStatus.DELIVERED;

typeShipment.deliverTime=block.timestamp;

uint256 amount=shipment.price;


payable(shipment.sender).transfer(amount);

shipment.isPaid=true;

typeShipment.isPaid=true;


emit ShipmentDelivered(_sender, _receiver, shipment.deliverTime);

emit ShipmentPaid(_sender, _receiver, amount);

}


function getShipment(address _sender, uint256 _index)public view returns(address,
    address,uint256,uint256,uint256,uint256,ShipmentStatus, bool){

    Shipment memory shipment=shipments[_sender][_index];

    return
    (shipment.sender,shipment.receiver,shipment.pickupTime,shipment.deliverTime
        ,shipment.distance,shipment.price,shipment.status,shipment.isPaid);

}


function getShipmentsCount(address _sender)public view returns (uint256){

    return shipments[_sender].length;

}

```

```
function getAllTransactions()public view returns (TypeShipment[] memory){
    return typeShipments;
}
}
```

Tracking.js

```
"use client";

//very important

import React, { useState, useEffect } from "react";

import { ethers } from "ethers";

import tracking from "../Conetxt/Tracking.json";

import web3Modal from "web3modal";

const ContractAddress = "0x5FbDB2315678afecb367f032d93F642f64180aa3";

const ContractABI = tracking.abi;

// console.log(ContractABI);

const fetchContract = (signerOrProvider) =>

    new ethers.Contract(ContractAddress, ContractABI, signerOrProvider);

export const TrackingContext = React.createContext();

export const TrackingProvider = ({ children }) => {

    //STATE VARIABLE
```

```

const DappName = "Product Tracking Dapp";

const [currentUser, setCurrentUser] = useState("");

const createShipment = async (items) => {

  console.log(items);

  const { receiver, pickupTime, distance, price } = items;

  try {

    const web3modal = new web3Modal();

    const connection = await web3modal.connect();

    const provider = new
ethers.providers.Web3Provider(connection);

    const signer = provider.getSigner();

    const contract = fetchContract(signer);

    const createItem = await contract.createShipment(

      receiver,

      new Date(pickupTime).getTime(),

      distance,

      ethers.utils.parseUnits(price, 18),

      {

        value: ethers.utils.parseUnits(price, 18),

      }

    );

    await createItem.wait();

    console.log(createItem);
  }
}

```

```

    } catch (error) {

        console.log("error in createShipment");

        console.log(error);

    }

};

const getAllShipment = async () => {

    try {

        const provider = new ethers.providers.JsonRpcProvider();

        const contract = fetchContract(provider);

        // console.log(provider.getCode(address))

        // console.log(contract);

        const shipments = await contract.getAllTransactions();

        console.log(shipments);

        const allShipments = shipments.map((shipment) => ({

            sender: shipment.sender,

            receiver: shipment.receiver,

            price: ethers.utils.formatEther(shipment.price.toString()),

            pickupTime: shipment.pickupTime.toNumber(),

            deliverTime: shipment.deliverTime?.toNumber(),

            distance: shipment.distance.toNumber(),

            isPaid: shipment.isPaid,

            status: shipment.status,

        }));

        console.log(`getAllShipment`);
    }
}

```

```

        console.log(allShipments);

        return allShipments;
    } catch (error) {

        console.log("error in getallShipment");

        console.log(error);

    }
};

const getShipmentCount = async () => {

    try {

        if (!window.ethereum) return "Install MetaMask";

        const accounts = await window.ethereum.request({

            method: "eth_accounts",

        });

        const provider = new ethers.providers.JsonRpcProvider();

        const contract = fetchContract(provider);

        const shipmentsCount = await
contract.getShipmentsCount(accounts[0]);

        console.log(shipmentsCount);

        return shipmentsCount.toNumber();

    } catch (error) {

        console.log(`get all Shipments `);

        console.log(error);

    }

};

```

```

const completeShipment = async (completeShip) => {

  console.log(completeShip);

  const { receiver, index } = completeShip;

  try {

    if (!window.ethereum) return "Install MetaMask";

    const accounts = await window.ethereum.request({

      method: "eth_accounts",

    });

    const web3modal = new web3Modal();

    const connection = await web3modal.connect();

    const provider = new
ethers.providers.Web3Provider(connection);

    const signer = provider.getSigner();

    const contract = fetchContract(signer);

    const transaction = await contract.completeShipment(

      accounts[0],

      receiver,

      index,

      {

        gasLimit: 300000,

      }

    );

    transaction.wait();
  }
}

```

```

        console.log(transaction);

    } catch (error) {

        console.log("wrong completeShipment", error);

    }

};

const getShipment = async (index) => {

    console.log(index * 1);

    try {

        if (!window.ethereum) return "Install MetaMask";

        const accounts = await window.ethereum.request({

            method: "eth_accounts",

        });

        const web3modal = new web3Modal();

        const connection = await web3modal.connect();

        console.log("1");

        const provider = new

ethers.providers.Web3Provider(connection);

        console.log("2");

        const contract = fetchContract(provider);

        console.log("3");

        console.log(accounts[0]);

        const shipment = await contract.getShipment(accounts[0], index

* 1);

        console.log("4");

```

```

const SingleShipment = {
    sender: shipment[0],
    receiver: shipment[1],
    pickupTime: shipment[2].toNumber(),
    deliveryTime: shipment[3].toNumber(),
    distance: shipment[4].toNumber(),
    price: ethers.utils.formatEther(shipment[5].toString()),
    status: shipment[6],
    isPaid: shipment[7],
};

return SingleShipment;
} catch (error) {
    console.log("single shipment error: ", error);
}
};

```

```

const startShipment = async (getProduct) => {
    const { receiver, index } = getProduct;
    console.log(getProduct);

    try {
        if (!window.ethereum) return "Install MetaMask";
    }
}

```

```

const accounts = await window.ethereum.request({
    method: "eth_requestAccounts",
});

const web3modal = new web3Modal();

const connection = await web3modal.connect();

const provider = new
ethers.providers.Web3Provider(connection);

const signer = provider.getSigner();

const contract = fetchContract(signer);

const shipment = await contract.startShipment(
    accounts[0],
    receiver,
    index * 1
);

shipment.wait();

console.log(shipment);
} catch (error) {
    console.log("sorry no shipment", error);
}
};

```

//Check wallet

```

const checkWalletConnected = async () => {
    try {
        if (!window.ethereum) {

```

```

        console.log("Install MetaMask");

        return "Install MetaMask";

    }

    const accounts = await window.ethereum.request({
        method: "eth_requestAccounts",
    });

    // console.log("Accounts:", accounts);

    if (accounts.length) {
        setCurrentUser(accounts[0]);
    }
} catch (error) {
    console.error("Error in checkWalletConnected:", error);
    throw error; // Rethrow the error or handle it as needed
}

};

const connectWallet = async () => {
    try {
        if (!window.ethereum) return "Install MetaMask";

        const accounts = await window.ethereum.request({
            method: "eth_requestAccounts",

```

```

    });

    console.log(accounts);

    setCurrentUser(accounts[0]);

  } catch (error) {

    console.log("error while wallet connection");

    console.log(error);

  }

};

const getBalance = async () => {

  try {

    if (!window.ethereum) {

      console.log("Install MetaMask");

      return "Install MetaMask";

    }

    const accounts = await window.ethereum.request({

      method: "eth_requestAccounts",

    });

    const provider = new

ethers.providers.Web3Provider(window.ethereum);

    const balance = await provider.getBalance(accounts[0]);

    // Convert the balance to a readable format (in Ether)

    const formattedBalance = ethers.utils.formatEther(balance);

```

```

        console.log("Account Balance:", formattedBalance);

        return formattedBalance;
    } catch (error) {
        console.error("Error in getBalance:", error);
        throw error; // Rethrow the error or handle it as needed
    }
};

```

```

useEffect(() => {
    checkWalletConnected();
});

return (
    <TrackingContext.Provider
        value={{
            connectWallet,
            createShipment,
            getAllShipment,
            completeShipment,
            getShipment,
            startShipment,
            getShipmentCount,
            getBalance,

```

```

        DappName,
        currentUser,
    }}
>
    {children}
</TrackingContext.Provider>
);
};

```

Deploy.js

```

const hre = require("hardhat");

async function main() {

    const Tracking = await hre.ethers.getContractFactory("Tracking");
    const tracking = await Tracking.deploy();

    await tracking.deployed();

    console.log(
        `Tracking deployed to ${tracking.address}`
    );
}

```

```
}
```

```
main().catch((error) => {  
  console.error(error);  
  process.exitCode = 1;  
});
```

```
//0x5FbDB2315678afecb367f032d93F642f64180aa3
```

Page.js

```
import HomePage from "@/Components/HomePage";  
import { TrackingProvider } from "../../Conetxt/Tracking";  
export default function Home() {  
  return (  
    <>  
      <TrackingProvider>  
        <HomePage/>  
      </TrackingProvider>  
    </>  
  );  
}
```

Layout.js

```
import { Inter } from "next/font/google";  
import "./globals.css";
```

```

const inter = Inter({ subsets: ["latin"] });

export const metadata = {
  title: "Create Next App",
  description: "Generated by create next app",
};

export default function RootLayout({ children }) {
  return (
    <html lang="en">
      <body className={inter.className}>{children}</body>
    </html>
  );
}

```

HomePage.jsx

```

"use client";

import React, { useContext, useState, useEffect } from "react";
import Navbar from "./Navbar";
import Footer from "./Footer";
import { TrackingContext } from "../../Conetxt/Tracking";
import Services from "./Services";

```

```

import Table from "./Table";

import Form from "./Form";

import Profile from "./Profile";

import CompleteShipment from "./CompleteShipment";

import GetShipment from "./GetShipment";

import StartShipment from "./StartShipment";

const HomePage = () => {
  const {
    currentUser,
    createShipment,
    getAllShipment,
    completeShipment,
    getShipment,
    startShipment,
    getShipmentCount,
    getBalance
  } = useContext(TrackingContext);

  //State variable

  const [createShipmentModel, setCreateShipmentModel] = useState(false);

  const [openProfile, setOpenProfile] = useState(false);

  const [startModal, setStartModel] = useState(false);

  const [completeModal, setCompleteModel] = useState(false);

  const [getModel, setGetModel] = useState(false);

```

```

//data state variables

const [allShipmentsData, setAllShipmentsData] = useState();

useEffect(() => {
    const fetchData = async () => {
        try {
            const campaignsData = await getAllShipment();
            console.log(campaignsData);
            setAllShipmentsData(campaignsData);
        } catch (error) {
            console.error("Error fetching data:", error);
        }
    };

    fetchData();
}, []);

return (
    <div>

        <Navbar />

        <Services

            setOpneProfile={setOpenProfile}

            setCompleteModel={setCompleteModel}

```

```

        setGetModel={setGetModel}

        setStartModel={setStartModel}
    />

    <Table

        setCreateShipmentModel={setCreateShipmentModel}

        allShipmentsData={allShipmentsData}
    />

    <Form

        createShipmentModel={createShipmentModel}

        createShipment={createShipment}

        setCreateShipmentModel={setCreateShipmentModel}
    />

    <Profile

        openProfile={openProfile}

        setOpenProfile={setOpenProfile}

        currentUser={currentUser}

        getShipmentCount={getShipmentCount}

        getBalance={getBalance}
    />

    <CompleteShipment

        completeModal={completeModal}

        setCompleteModel={setCompleteModel}

        completeShipment={completeShipment}

```

```

        />
        <GetShipment
            getModel={getModel}
            setGetModel={setGetModel}
            getShipment={getShipment}
        />

        <StartShipment
            startModal={startModal}
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        />

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    </div>

    );

};

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```

B. RESEARCH PAPER

Supply Chain Management of Pharmaceutical Drugs using Blockchain

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Abstract. Many produced goods that are essential to our everyday routines have made our lives easier in the modern world. Because manufactured goods are more plentiful and of higher quality, the Industrial Revolution has resulted in their widespread use. The management field's notion of a supply chain originated from the process of creating and delivering these goods. The different logistical procedures needed to produce a finished good make up a supply chain. Obtaining raw materials, turning them into completed goods, moving and distributing them among merchants and wholesalers, and delivering them to the final customer are all included in this. Because there are a lot of people and procedures involved, managing the entire process can be difficult and can result in inconsistent data and improper information handling. In the conventional method, customers are also unaware of the product's origins. To give customers and supply chain participants a single source of truth, we have created a blockchain-based solution.

INTRODUCTION

In light of the recent global health crisis, the healthcare industry has faced unprecedented challenges. One of the critical areas where these challenges have become glaringly evident is in the supply chain management of medical resources and equipment. The intricacies of procuring, distributing, and tracking vital medical supplies, including pharmaceuticals, medical devices, and personal protective equipment (PPE), have highlighted the need for a robust and innovative solution. Enter blockchain technology, and more specifically, the Ethereum blockchain, which promises to revolutionize the healthcare supply chain landscape.

The healthcare industry faces several challenges in managing the supply chain, such as counterfeit drugs and medical equipment, inefficient inventory management, lack of transparency in transaction records, and regulatory compliance issues. These problems not only pose a threat to patient safety but also have severe financial implications for healthcare providers. However, by embracing Ethereum blockchain technology, medical supply chain management can be significantly improved, offering a comprehensive solution to these challenges along with additional benefits.

The project aims to investigate how Ethereum blockchain technology can transform the management of medical supply chains. We will explore the various advantages of using Ethereum blockchain, such as transparency, traceability, immutability, and smart contracts, and illustrate how these features can enhance the efficiency, security, and reliability of medical supply chains. Additionally, we will examine real-world examples where Ethereum blockchain is already being used to improve medical supply chain operations. By the end of this study, readers will not only understand the potential advantages of integrating Ethereum blockchain but also realize how it can improve patient care, streamline operational efficiency, and establish a more resilient healthcare system. This integration can prove to be even more critical in the face of unforeseen challenges like pandemics and global supply chain disruptions.

Blockchain - A brief overview

Blockchain technology, characterized by its decentralized and distributed ledger system, employs cryptography to facilitate secure, transparent, and immutable transaction record-keeping. Operating on a peer-to-peer network, numerous nodes collaborate to validate and uphold ledger integrity. This innovation has the potential to revolutionize diverse industries by introducing a decentralized and trustless system, eliminating the necessity for intermediaries and centralized authorities. Offering a secure and tamper-proof data storage and sharing mechanism, blockchain is well-suited for use cases demanding transparency, accountability, and heightened security.

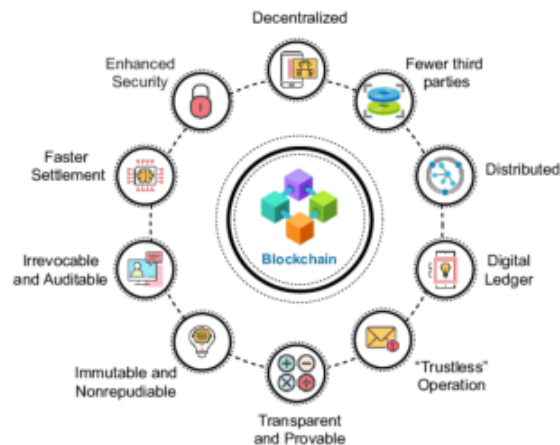


FIGURE 1. Features of Blockchain

The fundamental principles of blockchain include:

1. **Decentralization:** The degree of decentralization in a blockchain network is contingent upon the global distribution of its nodes. In this network architecture, each node retains a copy of the blockchain, and there is no centralized authority governing the system. This configuration imparts a robust and resilient nature to the network by diminishing the likelihood of a single point of failure.
2. **Transparency:** Blockchain, a decentralized ledger, records transactions transparently. Participants hold copies, and new transactions are added through consensus. Its transparency fosters trust, allowing users to independently verify transactions. This technology has the potential to revolutionize industries by providing a secure and tamper-proof system for recording transactions.
3. **Immutability:** By employing cryptography, the blockchain establishes an unmodifiable chain of blocks, where each block is uniquely linked to the previous one through a cryptographic hash. This robust structure significantly complicates any attempts to alter or delete data on the blockchain, ensuring the steadfast integrity and accuracy of historical records.
4. **Security:** Blockchain, as a distributed ledger technology, utilizes sophisticated cryptographic methods to safeguard data and regulate access. Transactions undergo verification through consensus mechanisms like proof of work (PoW) or proof of stake (PoS), requiring substantial computational power and providing robust resistance to fraudulent activities and hacking attempts. The decentralized nature of blockchain eliminates the presence of a single point of failure, thereby establishing it as a highly secure and reliable technology applicable across various domains.

2. BLOCKCHAIN IN SUPPLY CHAIN

Blockchain technology has demonstrated significant potential to revolutionize supply chain management across various industries. It offers transparency, traceability, security, and efficiency that can address many of the longstanding challenges in supply chain operations. Here are some key ways blockchain is impacting the industry:

The blockchain technology offers an unchangeable record where all events and transactions taking place in the supply chain are recorded. This transparency allows all authorized participants to monitor the movement and status of goods in real time, from their point of origin to their final destination. This helps to minimize the possibility of deception and fraud within the supply chain. Blockchain technology has simplified the verification process for confirming the authenticity and provenance of products, particularly crucial in industries with stringent safety and

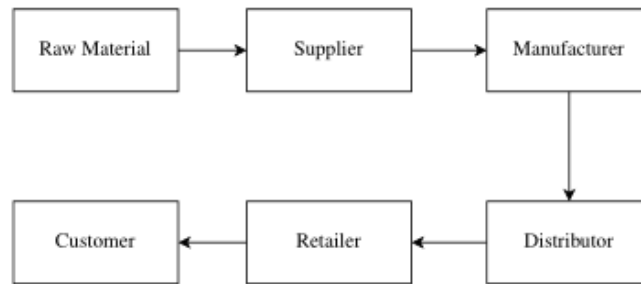


FIGURE 2. Stages of supply chain

regulatory requirements such as food and pharmaceuticals. Ensuring compliance and consumer safety is paramount. By performing a straightforward QR code scan on a product, consumers can promptly retrieve extensive information detailing the complete journey of the item through its entire supply chain.

The application of blockchain technology exploits its immutable ledger to establish a secure and tamper-resistant means of certifying the authenticity of products in the supply chain. This acts as a robust deterrent against the ingress of counterfeit goods. Blockchain enables real-time monitoring of inventory levels, location, and status, reducing overstocking, understocking, and manual tracking while saving costs and improving efficiency. Smart contracts are computer programs that enforce contract terms automatically. They operate on a secure, transparent digital ledger called a blockchain. Smart contracts can automate supply chain processes, reducing costs and increasing efficiency while providing transparency and security. In international trade, blockchain can facilitate near-instant settlement, reducing the time and costs associated with cross-border payments.

It can facilitate more accessible and efficient financing solutions for supply chains by providing transparent and auditable transaction records. This can benefit suppliers by improving cash flow and reducing financing costs. Blockchain can help industries, like pharmaceuticals and healthcare, ensure compliance by providing an immutable audit trail of all activities subject to strict regulatory requirements. The incorporation of blockchain technology establishes a robust and immutable system for managing sensitive data within the supply chain. Through the deployment of encryption and consensus mechanisms, blockchain ensures the confidentiality, integrity, and authenticity of information, significantly mitigating the risk of unauthorized access or alterations. Supply chain participants can receive real-time notifications about delays, temperature deviations, or quality issues, allowing for proactive problem-solving and risk mitigation. Blockchain can be utilized to monitor the environmental impact of goods during their entire life cycle, aiding organizations to make more sustainable decisions regarding their supply chain. Blockchain's decentralized nature eliminates single points of control or failure, improving supply chain resilience and reliability. Many real-world initiatives and consortia have been established to implement blockchain technology in supply chain management across various industries such as food, pharmaceuticals, and logistics.

2.1 Objectives

This study aims to enforce real-time visibility, enhanced tracking, and tracing of products and transactions in the supply chain. The improvement in traceability especially immutable and auditable records of supply chain movements as well as identifying product origin, authenticity, and quality are of key interest. We strive to enhance collaboration and trust through peer-to-peer interaction between stakeholders. Finally streamlining processes, increasing efficiency using automation and reduction in manual errors along with increased operational efficiency and cost savings can be achieved.

3. LITERATURE SURVEY

The incorporation of blockchain in the supply chain has been studied since the inception of blockchain technology, as it solves a fundamental and widespread issue in the global markets. This survey contains the survey of the recent

work of researchers from around the world and their findings.

Under the leadership of Saroj Kumar Nanda, a team of researchers has introduced a novel strategy for Healthcare Supply Chain Management (HSCM). This approach involves integrating emerging technologies with existing blockchain systems to enhance their capabilities. The proposed method specifically incorporates Internet of Things (IoT)-based sensors like RFID tags for real-time scanning and detection of products at each stage of the supply chain. Furthermore, the research team has developed a bi-objective mathematical model designed to minimize destination costs and reduce the occurrence of damaged items during public transportation. This pioneering technique holds the potential to revolutionize the management of healthcare supply chains, offering substantial improvements in both efficiency and cost savings. [1]

Blockchain technology plays a significant role in pharmaceutical traceability, as demonstrated by a noteworthy study by Smith and Johnson that emphasizes how the technology may provide an irreversible record of every drug's path from manufacturing to distribution. As a result, worries about illegal diversions and fake medications are allayed, guaranteeing the integrity and authenticity of pharmaceutical products. [2] An automated way to automate and enforce agreements in the pharmaceutical supply chain is through the use of smart contracts, a fundamental component of blockchain technology. Case studies that demonstrate how smart contracts improve transactional efficiency among stakeholders, decrease fraud, and streamline procedures are examined in research by Brown and Garcia. [3] In a study, Chen and Kim (2022) look into the cost and efficiency savings that blockchain technology can provide pharmaceutical supply chains. The study examines how supply chain efficiency is affected by blockchain technology, highlighting the areas in which these technologies work best to cut costs and improve operational effectiveness. [4]

The work of Davor Dujak and Domagoj Sajter lays the theoretical foundations of blockchain-based technologies and highlights the importance of traceability and visibility, the benefits of IoT and RFID technology, and how blockchain verifies data collected from IoT devices, with concrete examples and real-life implementations and companies in food and consumer goods industry. It also illuminated the various facets of supply chain industries and their inner working like demand forecasting, open access, fraud prevention, and transaction automatization. [5] Maher A.N. Agi et al.'s research presents a new approach to Decision-Making Trail and Evaluation Laboratory (DEMATEL), which helps extract insights and logic from data collected from 37 experts in France. These experts provide input on the impact of identified enablers and their interdependencies. The research also analyses the pressure points that are particularly influential in the adoption of blockchain technology in the supply chain. The paper describes the methodology used to analyse the influence of various enablers on blockchain adoption in the supply chain. [6]

The paper authored by Rita Azzi and her colleagues delves into the intricacies of integrating blockchain into the supply chain mainly to enhance the dependability, transparency, authenticity, and security of the supply chain. The paper acknowledges that conventional centralized supply chain management systems may expose the supply chain to issues such as corruption, fraud, and tampering. Therefore, a more robust and secure solution is necessary. The paper highlights the various components used in tracking systems, including tags, tracers, QR codes, RFID sensors, among others. Additionally, it outlines the associated challenges and vulnerabilities of centralized systems. The paper includes case studies of Modum and Ambrosus startups, which have developed a system that combines IoT, blockchain technology, and real-time sensors. This system traces and transmits product information throughout the entire manufacturing process. [7]

Sohail Jabbar and his colleagues have addressed the limitations of the current supply chain system. They have analyzed the consensus mechanism and proposed a new model, known as the MOHBSCChain model. This conceptual framework offers a potential solution to some of the challenges identified in the analysis. Its goal is to integrate the blockchain technology into the supply chain industry. [8] Abhiram Ravipati et.al. investigate the contemporary landscape of video surveillance and human activity recognition (HAR) systems. With the proliferation of surveillance cameras and diverse acquisition devices, the study addresses the challenges in recognizing human actions in video frames or photographs, including issues like background congestion, partial blockage, and variations in size, perspective, illumination, and appearance. Emphasizing the importance of multimodal recognition in fields such as CCTV and human-computer interaction, the paper explores the impact of breakthroughs in data extraction facilitated by AI. [9] The paper thoroughly discusses the technical as well as the non-technical aspects of blockchain technology. Some of the major non-technical include the lack of understanding, waiting for wider adoption, market acceptability, skill gap, data correctness, etc. Also, some of the pressing technical issues arise from the centralized and distributed architectures along with some primitive issues of the blockchain like scalability and interoperability. It highlights some prospective areas of research in the blockchain domain:

1. This platform has built-in analytics capabilities.
2. It allows for integration and analysis of both on-chain and off-chain data.

3. Smart contract templates can be developed on this platform.
4. The platform also provides security analysis for smart contracts.
5. Governance can be standardized and automated.
6. Encrypted data can be queried and executed on this platform.
7. Additionally, a Right-to-Forget mechanism can be incorporated.

Xiaxia Niu and Zeping Li combined research on the blockchain network on supply chain management based on blockchain showcases the structure and features of the blockchain but mainly highlights the problems associated with it such as delay in information transfer, lack of transparency, and weak traceability and how the blockchain is applied to the supply chain. [10] Francesco Longo et. al. develop a theoretical supply chain model that replicates supply chain operations. This model integrates with the blockchain with the software connector, enabling scenario-based statistical analysis, using an Ethereum-like blockchain, and provides the necessary implementation ideas for the same. [11]

3.1 Open Problems in the Existing System

- Existing traceability systems have problems.
- The architecture can be centralized or distributed.
- IoT and centralized cloud infrastructures.
- Data fragmentation is an issue.
- Lack of understanding and adoption.
- Scalability.
- Interoperability.

3.2 Comparative study

When blockchain applications are compared to traditional systems in pharmaceutical supply chain management, the results show improved security, traceability, and transparency. The risk of counterfeit pharmaceuticals is decreased by blockchain, which guarantees an unchangeable record of drug transactions. Processes are streamlined, errors are reduced, and efficiency is raised thanks to smart contracts. An auditable and secure trail helps with regulatory compliance. Furthermore, increased transparency and cooperation among stakeholders promote accountability and confidence. Blockchain's decentralized structure and cryptographic capabilities, in contrast to traditional techniques, provide a more robust and flexible solution to the pharmaceutical supply chain.

4. PROPOSED SYSTEM

The method involves utilizing a front end, back end, and a range of sensors. The front end consists of devices such as computers and mobile devices that users interact with, while the back end consists of an Ethereum blockchain network. As we transport goods from the manufacturer to the end-user, we equip various IoT devices such as temperature sensors, and location tags which allow us to collect real-time data from the drugs. They help us track the shipment, control the temperature, identify the carrier, ensure speedy delivery, and serve other purposes as well. In the case of medicinal drugs, the use of such IoT devices becomes even more critical as these products are delicate and can lose their efficacy if not handled carefully or delivered on time.

An SQL database is used to store the entity's sensitive information as the data stored in the blockchain is inherently public. The smart contract contains the code that allows the user to add, update, and retrieve data from the blocks in the chain. The user cannot interact with the blockchain directly. For this reason, we have created a web portal for the

interaction and an HTTP server for handling user requests. The users can use their phones, laptops, PCs, etc., to access the blockchain via the web server. We have used Ganache as the local blockchain environment to test and Infura as the service to deploy the code to a real chain for use. The main question that arises is what is the benefit of such an elaborate system for the consumer? The answer is simple. As consumers, we have no idea about the source, location, and creation time of the products we purchase. With this system in place, we can now access this information and have a better understanding of the products we buy. Not only the consumers, but every member associated with the blockchain benefits from this as they all know the source, location, creation time, and other essential details about the product that are often lost in the traditional supply chain system.

4.1 System Architecture

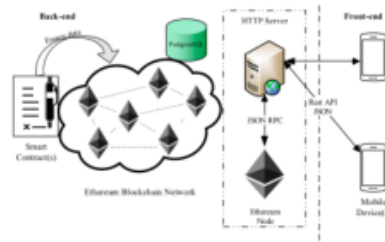


FIGURE 3. System Architecture

4.2 Modules

The system contains the following components:

- **Ethereum Blockchain Network:** This service is available to everyone and allows for easy access to data. It is particularly helpful for verifying front-end registered data. Smart contracts are executed on an Ethereum blockchain virtual machine, which is a key component of blockchain networks. These smart contracts play a crucial role in verifying data within the blockchain network.
- **HTTP Server:** An HTTP server serves as the intermediary between the front-end mobile and desktop devices and the back-end Ethereum network and is responsible for querying and data forwarding. We use Infura because it saves us the hassle of deploying and maintaining our servers.
- **Database:** A MySQL database is used to store user information that is private and can be exploited if present on the chain.
- **Smart Contracts:** Access control systems are supported by different operations. JSON RPC calls from the servers are used to communicate between the users and the blockchain.
- **IoT Devices:** The use of IoT devices is vital in the medical logistics field to guarantee the secure and safe transportation of products from the manufacturer to the end-user. IoT consists of physical devices that are equipped with various technologies such as software, electronic devices, sensors, QR codes, RFID tags, and barcode systems. These devices can collect and exchange data, which allows real-time monitoring and tracking of products during transportation.

4.5 Implementation Flow

Smart contracts which contain the logic of the system include the following contracts: drugs, types, entities, and supply chain contracts.

Each of these contracts has a pivotal role:

- **Drugs contract:** This contract contains the functions to add a drug to the supply chain, and allows the user to get the details of all or a specific drug in the chain.
- **Types contract:** This library defines the user-made structures that define the entities in the supply chain as well as the structure of the drugs.
- **Entities contract:** It has the code that allows an entity to be added and removed as well as other functions that allow it to check for an entity's presence in the supply chain.
- **Supply chain contract:** This contract defines the functions for payment and transfer of ownership of the drugs from one entity to another. It inherits from the entities and drug contracts.

Each contract contains encoded privileges which allow only the contract owners to perform the functions.



FIGURE 4. Implementation Flowchart

4.6 Advantages

A tag is attached to each batch of drugs that monitors the location of the batch and interactions between the entities. Using blockchain technology we can create a secure chain of records that contains information related to the manufacturers, drug authorities, distributors, and end-users, which facilitates product tracking and tracing. Blockchain technology eliminates the need for third-party verification during product transfer between manufacturer and customer. Unauthorized users find it difficult to alter information once it's entered into the blockchain. The data once sent in the blockchain is permanently registered and hence the owners have no control to alter it. Integrating IoT with Blockchain technology enables real-time sharing of product information among all parties transparently involved in a transaction. The use of smart contracts and blockchain technology can bring about a significant transformation in the field of freight and delivery services. With the help of blockchain data, smart contracts can ensure that contractual obligations are met, and payments are made at the right time. This can result in a streamlined and automated system for invoicing, payment processing, and physical transportation of goods, which can be cost-effective and easily auditable. Entity in the chain gets its fair share of money with no lags, and any excess amount sent is returned, as soon as the delivery is completed ensuring a speedy and transparent transaction.



FIGURE 5. Ownership transfer

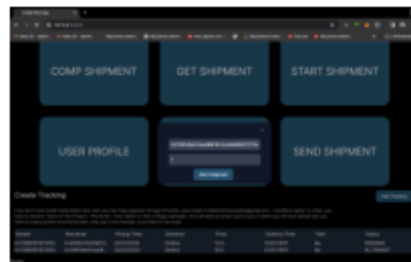


FIGURE 6. Allows the user to create a new shipment for a drug

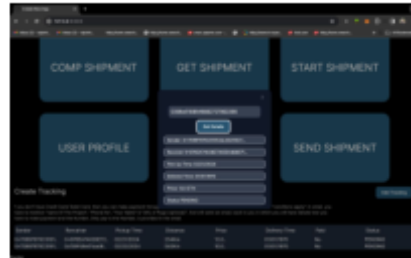


FIGURE 7. Allows the user to get the details of a particular shipment



FIGURE 8. Allows the user to finish the shipment process for a drug



FIGURE 9. Allows the user to get the details about himself

5. SOFTWARE REQUIREMENTS

- **Ethereum:** Ethereum is a decentralized blockchain platform known for smart contracts and decentralized applications (DApps). It introduced the concept of smart contracts, self-executing agreements written in code, and operates on its native cryptocurrency, Ether (ETH). Ethereum enables developers to build a variety of applications and token standards, fostering a vibrant ecosystem. It has a dynamic community and is undergoing upgrades, including the transition to Ethereum 2.0 for scalability improvements.
- **Remix IDE:** Remix IDE is a web-centric Integrated Development Environment (IDE) tailored for the purpose of Ethereum smart contract development. It features a built-in code editor, Solidity compiler, debugger, and testing environment, and supports deployment to Ethereum networks. It is accessible from any device with an internet connection and is known for its user-friendly interface and comprehensive toolset.
- **MetaMask wallet:** MetaMask is a browser extension and cryptocurrency wallet widely used in the Ethereum ecosystem. It enables users to manage Ethereum and ERC-20 tokens, securely interact with decentralized applications (DApps) from their browsers, and offers features like multiple account management and transaction history. It is known for its user-friendly interface and open-source nature.
- **Infura:** Infura is an infrastructure service provider for blockchain, particularly known for Ethereum. It offers a scalable API service that allows developers to access Ethereum networks without managing their own nodes. Developers use Infura to interact with the Ethereum blockchain, making it easier to build decentralized applications (DApps). Infura is recognized for its reliability, scalability, and user-friendly API, making it a popular choice for blockchain developers.
- **MySQL database:** MySQL, an open-source relational database management system (RDBMS), is extensively employed for the storage and management of structured data. It follows SQL standards, is cross-platform compatible, and offers features like data security, scalability, and robust community support. Commonly used in web development, MySQL is known for its efficiency in handling databases for various applications.
- **Hardhat:** Hardhat is a development environment and task runner for Ethereum smart contract projects. It streamlines the compilation, testing, and deployment processes, offering a local testing network, built-in scripts, and extensibility through plugins. Popular for its developer-friendly features, Hardhat is used alongside tools like Ethers.js for efficient Ethereum development.
- **Ganache:** Ganache is a development tool within the Truffle Suite, specifically designed for Ethereum blockchain development. It provides a local, in-memory blockchain network for testing and developing Ethereum-based applications. Ganache simplifies the development process by offering features like pre-configured accounts with Ether, control over mining processes, configurable gas settings, and a built-in blockchain explorer. Developers often use Ganache in conjunction with Truffle to streamline the creation, testing, and deployment of smart contracts and decentralized applications (DApps) in a controlled local environment.
- **HTML:** HTML (Hypertext Markup Language) stands as the standard language for crafting web content. Employing tags, HTML structures and formats text, images, links, and various elements within a webpage. Web browsers interpret HTML documents to render content on the internet.

- **CSS:** CSS (Cascading Style Sheets) is a styling language for web development that controls the appearance of HTML elements. It uses selectors and rules to define properties such as colours, fonts, and layout, ensuring the separation of content and presentation on websites.
- **JavaScript:** JavaScript (JS) serves as a versatile programming language predominantly applied for client-side scripting in web browsers. It facilitates the dynamic creation of interactive web pages, executing directly within the user's browser while adhering to the ECMAScript standard. Its utility extends to server-side operations, notably through platforms like Node.js, and spans diverse application domains. With an extensive array of libraries and frameworks, asynchronous programming support, and its integral role in modern web development, JavaScript stands as a cornerstone in the technical landscape.

6. DISCUSSION

It would be too optimistic to believe that this blockchain-based system is entirely fault-proof and acts as a silver bullet to all supply chain-related issues. We must realize that the blockchain is still a nascent technology and its current implementation and applications are limited. The modules and packages are rapidly being updated hence creating friction for developers and users. This software created for supply chain management has its flaws, one of which is its intense dependence on the wallet. This piece of software depends on the wallet component to sign the various transactions and deduct and deposit ethers from and to various Ethereum storehouses of the various entities in the supply chain. This wallet dependence also means that an entity cannot register in the supply chain if it does not have a wallet and hence cannot be a part of the supply chain processing. Another shortcoming is, that we have not created the wallet that is utilized so its invalidity in the future could cause a serious threat to the software.

The implementation does not include fail safes for edge cases which might occur in a pragmatic supply chain. The design assumes a simple linear supply chain and workflow, but in practice, the supply chain of a drug can be far more cumbersome, under such circumstances further improvements and additions need to be done in the source code and design architecture of the system. The room for further improvement is always present and dwelling on improved design strategies, less cohesive modules, the incorporation of artificial intelligence for automated fault rectification, improved user experience and more robust implementation remains open.

7. CONCLUSION

In recent years, the healthcare industry has faced acute challenges in supply chain management, especially underscored by the global health crisis. The intricate nature of procuring, distributing, and tracking medical resources necessitates a robust solution. Blockchain, particularly Ethereum, emerges as a transformative technology to address issues like counterfeit drugs, inefficient inventory management, and transparency gaps. This project focuses on leveraging Ethereum blockchain's features – transparency, traceability, immutability, and smart contracts – to enhance medical supply chain efficiency, security, and reliability. Real-world instances showcase the practical ramifications of integrating the Ethereum blockchain into the operational framework of medical supply chains.

The research aims to provide a detailed technical insight into how Ethereum blockchain can revolutionize healthcare supply chain management. By delving into the intricacies of the technology, the study showcases its potential to not only optimize operational processes but also fortify the healthcare system's resilience in the face of unforeseen challenges, such as pandemics and global disruptions.

REFERENCES

1. S. K. Nanda, S. K. Panda, and M. Dash, "Medical supply chain integrated with blockchain and iot to track the logistics of medical products," *Multimedia Tools and Applications*, 1–23 (2023).
2. J. A. Smith J., "Blockchain technology in pharmaceutical supply chain: A comprehensive review," *Journal of Supply Chain Management* **25**, 112–130 (2020).
3. G. R. Brown M., "Smart contracts for pharmaceutical logistics: A case study approach," *International Journal of Logistics Technology and Management* **12**, 78–94 (2021).
4. K. Y. Chen L., "Efficiency gains and cost reduction through blockchain in pharmaceutical supply chain," *International Journal of Operations and Production Management* **42**, 45–63 (2022).

5. D. Dujak and D. Sajter, "Blockchain applications in supply chain," *SMART supply network*, 21–46 (2019).
6. M. A. Agi and A. K. Jha, "Blockchain technology in the supply chain: An integrated theoretical perspective of organizational adoption," *International Journal of Production Economics* **247**, 108458 (2022).
7. R. Azzi, R. K. Chamoun, and M. Sokhn, "The power of a blockchain-based supply chain," *Computers & industrial engineering* **135**, 582–592 (2019).
8. S. Jabbar, H. Lloyd, M. Hammoudeh, B. Adebisi, and U. Raza, "Blockchain-enabled supply chain: analysis, challenges, and future directions," *Multimedia systems* **27**, 787–806 (2021).
9. A. Ravipati, R. K. Kondamuri, M. Posonia, *et al.*, "Vision based detection and analysis of human activities," in *2023 7th International Conference on Trends in Electronics and Informatics (ICOEI)* (IEEE, 2023) pp. 1542–1547.
10. X. Niu and Z. Li, "Research on supply chain management based on blockchain technology," in *Journal of Physics: Conference Series*, Vol. 1176 (IOP Publishing, 2019) p. 042039.
11. F. Longo, L. Nicoletti, A. Padovano, G. d'Atri, and M. Forte, "Blockchain-enabled supply chain: An experimental study," *Computers & Industrial Engineering* **136**, 57–69 (2019).
12. S. Chen, R. Shi, Z. Ren, J. Yan, Y. Shi, and J. Zhang, "A blockchain-based supply chain quality management framework," in *2017 IEEE 14th international conference on e-business engineering (ICEBE)* (IEEE, 2017) pp. 172–176.
13. S. Bhalerao, S. Agarwal, S. Borkar, S. Anekar, N. Kulkarni, and S. Bhagwat, "Supply chain management using blockchain," in *2019 international conference on intelligent sustainable systems (ICISS)* (IEEE, 2019) pp. 456–459.
14. K. Nirantar, R. Karmakar, P. Hiremath, and D. Chaudhari, "Blockchain based supply chain management," in *2022 3rd international conference for emerging technology (INCET)* (IEEE, 2022) pp. 1–8.
15. C. Singh, R. Thakkar, and J. Warraich, "Blockchain in supply chain management," *European Journal of Engineering and Technology Research* **7**, 60–69 (2022).
16. A. Chang, N. El-Rayes, and J. Shi, "Blockchain technology for supply chain management: A comprehensive review," *FinTech* **1**, 191–205 (2022).
17. R. Casado-Vara, A. González Briones, J. Prieto, and J. Corchado Rodríguez, "Smart contract for monitoring and control of logistics activities: Pharmaceutical utilities case study," (2019) pp. 509–517.