Supply Chain Management Using Blockchain

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Abstract:- Yes, that's correct! The paper proposes a solution that utilizes blockchain and AI technologies to ensure the secure and transparent distribution of medical drugs across the supply chain. The system employs smart contracts and a Rasa chatbot integrated into a Flutter app to enable ordering and traceability of medicines. Additionally, the system includes a blockchain-based credit evaluation mechanism to enhance the trustworthiness of the supply chain participants. The smart contracts are deployed on a local blockchain provided by Ganache, and the DApp is connected to the blockchain using Web3.js and Truffle framework.

The system also includes trade chain and information chain platforms to construct an overall framework of the supply chain system. Platform interaction rules are formulated to standardize the system information exchange format and ensure the stability and efficiency of system interaction. Smart contracts are a type of digital contract that is designed to automatically execute predefined actions when certain conditions are met. In the context of supply chain systems, smart contracts can be used to facilitate and manage transactions between different parties, as well as to ensure the accuracy and integrity of supply chain information. By using smart contracts, supply chain stakeholders can improve the efficiency of their interactions, reduce transaction costs, and enhance the security and reliability of their data.

The experimental results show that the proposed system is feasible and comparatively more secure than existing systems. While the system realizes the basic functions of the supply chain, it also promotes the sharing of information between participants and improves its efficiency.

Summary of the text: The text discusses the application of blockchain in supply chain management, specifically for product traceability, and mentions the use of smart contracts to automate processes. The problem of drug counterfeiting is highlighted as a particular area where blockchain can provide benefits. The integration of artificial intelligence and Rasa is also briefly mentioned. The text concludes by emphasizing the need for further research and development in the practical applications and architectures of blockchain in supply chain management.

Keywords:
- *Blockchain*
- *Ethereum*
- *Smart contracts*
- *Product traceability*
- *Supply chain*
- *Drug counterfeiting*

I. INTRODUCTION

A supply chain is a network of organizations involved in various processes that produce products and services for the end customer. Global supply chains are complex and involve multiple borders, transactions, and knowledge. In 2018, global merchandise exports amounted to $19.48 trillion, while more than $16 trillion worth of goods are shipped across international borders each year, with an estimated yearly cost of $1.8 trillion. Removing barriers in the international supply chain could boost the global economy by almost 15% and create new job opportunities.

In supply chains, products are owned by different organizations at various stages until they reach the end consumer. For products with lower added value, such as agricultural commodities and some mining commodities, the supply chain serves as a way to aggregate goods from many small-scale producers and deliver them to larger-scale partners for further processing into final products.

The traditional supply chain model starts with manufacturers and importers sending products to the next stage, which is the middle layer that includes wholesalers. The middle layer processes the products received from manufacturers and importers and then supplies them to the last step, which is the retailer or food service that sells products to consumers. However, the main problem with this model is that the data is not easily accessible to all participants in the supply chain, including consumers. This makes it difficult for consumers to verify the origin and quality of the products they purchase.

The current supply chain systems do not provide reliable data to consumers, and the problem is even more complex in global supply chains. To establish a trustworthy system, blockchain technology has emerged as a disruptive solution. By transitioning to blockchain-based supply chain solutions, it

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is possible to overcome the challenges faced by the existing supply chain models. Participants in a blockchain integrated supply chain have defined roles, and the tipping point for adoption of this technology is expected to be when 10% of global GDP is stored on blockchain ledgers by 2027.

This paper provides a comprehensive overview of the potential benefits, obstacles, and potential areas of investigation related to the integration of blockchain technology in supply chain management. Our aim is to provide a foundation and roadmap for future research in this area.

II. BLOCKCHAIN

In simpler terms, blockchain is a way to store information across a network of computers, without relying on a central authority or intermediary. Put differently, a blockchain system operates in a decentralized manner, where no single entity has full control or authority over the entire network. Satoshi Nakamoto is credited with originating the concept of digital currency using blockchain technology[1]. Since then, blockchain has evolved and holds promise in many different domains, thanks to its ability to provide security, traceability, and transparency. The way blockchain works is that every transaction is turned into a hash; the hash is dependent not only on current transaction but also on previous hashes [2].After a transaction is confirmed by miners, it is recorded on the blockchain in the order that it occurred, creating an unalterable and time-stamped ledger of all transactions. A blockchain is formed by connecting individual blocks in a chronological order, where each block is linked to the one preceding it.. Blockchains are distributed databases that store information Blockchain is a technology that operates on a network of computers, known as nodes, and allows for decentralized storage and peer-to-peer transactions. The data in a blockchain is replicated and updated on all nodes in real-time, ensuring that all copies of the database remain consistent and up-to-date. What makes blockchain secure is that the data is stored on multiple computers, therefore, a major security breach would require data corruption on a multitude of computers [3].To tamper with the data stored in a blockchain, a hacker would need to modify the hash of each block that comes after the targeted block. This is because the hash of each block is dependent on the data in the previous block, and any alteration to the previous block would result in a different hash. Therefore, the integrity of the entire blockchain is maintained and it becomes extremely difficult for a hacker to tamper with the data in the blockchain[4].

Public blockchains allow anyone to participate in the network and add transactions, while private blockchains restrict participation to a select group of users who have permission to add transactions. Open vs. In other words, a closed blockchain restricts access to only participants with permission to retrieve transactions, while an open blockchain allows full public access to retrieve transactions. A closed blockchain allows participants with permission to retrieve transactions. [5]. Supply chain participants consist of manufacturers, suppliers, storers, logistics providers, processers, etc., each of them has terms and conditions among participants. Smart contracts on blockchain technology enable the implementation of supply chain rules and facilitate automated execution of transactions between different parties involved in the supply chain. A supply chain that uses smart contracts can simplify processes for multiple parties involved by requiring their digital signatures for agreements, shipments, and compliance checks. For instance, a manufacturer can send a shipment after receiving an order from a supplier, and a regulatory authority can ensure compliance for components of a product[7].

A smart contract is just another software program that constitutes a set of conditions and is executed automatically once those conditions are met. (Blockchains can be utilized for various purposes, including the transfer of funds, ownership, and executing the terms of a contract, among others).Various programming languages can be used to create smart contracts on blockchain networks. Some of the popular programming languages used for writing smart contracts include Solidity, Rust, Yul, Vyper, and DAML. Each of these programming languages has its own syntax, semantics, and features that enable developers to create smart contracts with different functionalities and capabilities. So, in other words, different blockchain code languages such as Solidity, Rust, Yul, Vyper, and DAML can be utilized to write smart contracts[8]. Another benefit of smart contracts is decreasing risk, and cost, removing intermediaries on one side, and increasing accuracy, speed, and real-time updates in business process on the other side.Smart contracts are digital programs that can be self-executing, self-enforcing, and governed by business logic among multiple parties. In other words, once a smart contract is deployed on a blockchain network, it can automatically execute its code based on predefined rules and conditions, without the need for intermediaries or human intervention. The code of the smart contract is designed to enforce the terms and conditions of the agreement between the parties involved, and it cannot be altered or manipulated once it is deployed. This makes smart contracts a secure and reliable way for parties to transact with each other without the need for trust or intermediaries.[9]

The second section of our paper aims to provide context by giving a brief overview of the history of blockchain. This is done to help readers understand how blockchain technology has evolved over time and how it has become an important aspect of various industries and sectors. The section covers the early beginnings of blockchain technology, including the creation of Bitcoin in 2009, and its subsequent adoption by various communities.

It also discusses the development of other blockchain networks, such as Ethereum, and how they have expanded the capabilities of blockchain technology beyond just cryptocurrency transactions. The section also touches upon the challenges faced by blockchain technology, such as scalability and security, and how various solutions have been proposed to address them.

Overall, section 2 serves as a foundation for the rest of the paper, providing readers with a broad understanding of the history and evolution of blockchain technology. In section 3, our paper discusses how blockchain technology can be utilized in smart contracts to transform traditional, centralized supply chains into more efficient and secure systems. The section also highlights how blockchain can be used in conjunction with IoT devices to create a more robust and reliable system for tracking and recording data.

Section 4 of the paper focuses on the fundamental requirements for selecting a suitable blockchain network. These requirements include considerations such as transactional fees, data transfer rates, data security, the ability to write and execute smart contracts, and the availability of software development kits. These factors are crucial in determining the feasibility and suitability of a particular blockchain network for a specific use case or application.

The section delves into each of these requirements in detail, discussing their significance and impact on the overall performance and functionality of a blockchain network. By providing this information, section 4 aims to guide decision-makers in selecting the most appropriate blockchain network for their specific needs and requirements.

various blockchain networks and places emphasis on the Solana blockchain.Section 5 of the article details a prototype blockchain software architecture that focuses on traceability in smart contracts. The proposed architecture utilizes the Sigfox platform for IoT, which enables seamless communication between IoT devices, cloud, and blockchain.

The architecture is designed to ensure that data recorded on the blockchain is transparent, tamper-proof, and traceable. The Sigfox platform plays a crucial role in facilitating this by providing secure and reliable connectivity between the IoT devices and the blockchain network.

The section provides an in-depth technical overview of the software architecture, including the components involved, the interactions between them, and the protocols used for communication. The section also discusses how the prototype was implemented and tested, highlighting its strengths and limitations.

Overall, section 5 demonstrates the potential of blockchain technology to enhance traceability in supply chain management and other industries. By leveraging the Sigfox platform for IoT, the proposed architecture provides a robust and secure framework for tracking and recording data on the blockchain, enabling greater transparency and accountability in supply chain operations. This architecture enables interaction between the IoT device, cloud, and blockchain, allowing for a more efficient and secure way of tracking and recording data on the blockchain.

The web application and dashboards are designed to provide an easy-to-use interface for users to interact with the blockchain and view the data recorded on it. The technical design ensures that the software is secure and reliable, with features such as encryption and data backup implemented to safeguard against cyber threats.

The libraries used in the development of the software enable seamless integration with the Solana blockchain, allowing for efficient and reliable transactions. The section provides an overview of the technical architecture of the software, including the various components and their functionalities.

Overall, section 6 highlights the potential of blockchain technology in creating robust and secure software solutions. By leveraging the Solana blockchain and implementing best practices in software development, the prototype software developed in this study demonstrates how blockchain technology can be used to enhance supply chain management and other applications. The web application and dashboards are designed to provide easy and intuitive interfaces for users to interact with the blockchain and view the data recorded on it. The technical design of the software ensures that it is secure and reliable, while the use of libraries facilitates integration with the Solana blockchain, making it easier for developers to build blockchain-based applications..

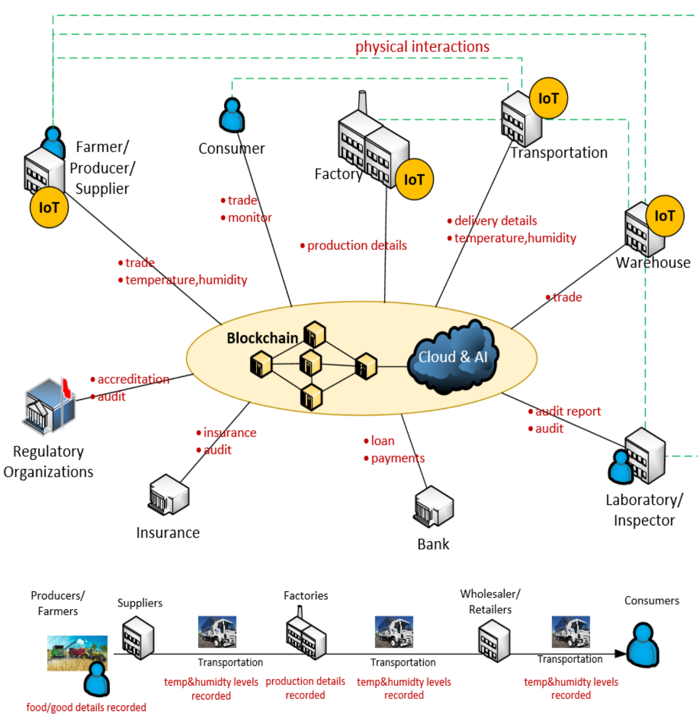

Fig. 1. Participants and their roles in a typical blockchain integrated supply chain flow

III. EVOLUTION OF BLOCKCHAIN

Over the past decade, blockchain technology has seen rapid progress and evolution. The emergence of Blockchain 2.0 and Blockchain 3.0 has played a significant role in this progression. Blockchain 2.0 is primarily associated with the development of smart properties and smart contracts, which are specifically designed for use in cryptocurrency transactions. Popular blockchain networks that fall under this category include Ethereum, NEO, and QTUM.

Blockchain 3.0, on the other hand, is geared towards applications beyond just financial transactions. This includes sectors such as healthcare, logistics, and supply chain management. Blockchain networks that fall under this category are designed to provide enhanced security and transparency, while also facilitating automation and efficiency in various non-financial sectors.

Overall, the emergence of Blockchain 2.0 and 3.0 has expanded the capabilities and applications of blockchain technology beyond just cryptocurrency transactions. This has opened up new possibilities for innovation and development, with blockchain poised to play a significant role in various industries and sectors in the future[10].Today blockchain applications exist It is not surprising that blockchain technology has gained significant popularity in the supply chain sector and other industries. With increasing globalization and trade, there is a growing need for secure and transparent methods of exchanging data and information between different parties.

Blockchain technology provides a decentralized and immutable ledger that can securely store and share data, making it an ideal solution for supply chain management and other applications. By leveraging blockchain, supply chain stakeholders can increase efficiency, reduce costs, and improve overall transparency and accountability.

Moreover, blockchain technology has the potential to provide benefits beyond just supply chain management. It can be used to enhance cybersecurity, streamline financial transactions, and improve the efficiency of various business processes. As a result, blockchain technology is being explored and adopted in various industries, from healthcare to finance to real estate.

Overall, the popularity of blockchain technology is expected to continue to grow as its potential benefits become more widely recognized and adopted in various sectors. blockchain technology gains wider adoption, it has become increasingly common for multiple parties to be involved in a single transaction. This is particularly true in supply chain management, where numerous stakeholders may be involved in the production, transportation, and distribution of goods.

By leveraging blockchain technology, these stakeholders can securely and transparently share data and information with one another, allowing for greater collaboration and efficiency in the supply chain. This can include everything from tracking the origin and quality of raw materials to monitoring the transportation and delivery of finished products.

The use of blockchain in supply chain management has the potential to streamline processes, reduce costs, and improve overall transparency and accountability. As a result, it is expected that more and more parties will become involved in these transactions as the benefits of blockchain technology become more widely recognized and adopted. The integration of blockchain technology with smart contracts, cloud computing, and Internet of Things (IoT) devices has the potential to create smart automated interfaces that eliminate the need for intermediaries or other third parties.

By leveraging blockchain technology, smart contracts can be securely and transparently executed without the need for intermediaries such as banks or legal institutions. Cloud computing can provide a platform for hosting and executing these smart contracts, while IoT devices can be used to automate various aspects of the supply chain process.

The result is a more efficient and streamlined supply chain that is less reliant on human intervention and manual processes. With blockchain technology and smart contracts, transactions can be executed automatically based on predefined conditions, reducing the need for intermediaries and reducing transaction times.

Overall, the integration of blockchain with smart contracts, cloud computing, and IoT devices has the potential to revolutionize various industries, from supply chain management to healthcare to finance. By eliminating intermediaries and automating processes, businesses can become more efficient, cost-effective, and transparent. Smart contracts, which use contractual clauses to perform certain actions depending on the fulfillment of those clauses, vastly expand the applications that blockchain can perform. The SC industry in specific could see a major shift due to this type of technology because of the automation,

IV. SMART SUPPLY CHAIN

A smart environment can be defined as a physical world that is seamlessly and invisibly interwoven with sensors, actuators, displays, and computational elements that are embedded in everyday objects. These elements are designed to collect, process, and transmit data in real-time, allowing for greater automation, control, and optimization of various systems and processes.

Smart environments can include everything from smart homes and buildings to smart cities and transportation systems. They leverage a combination of technologies such as

IoT devices, sensors, and data analytics to create intelligent and connected systems that can improve efficiency, safety, and sustainability.

In a smart environment, sensors and other devices are interconnected through a network and are able to communicate with one another to perform various tasks automatically. For example, in a smart home, sensors can detect the presence of occupants and adjust the temperature and lighting accordingly, while also providing data to the homeowner about energy consumption and other factors.

Overall, the development of smart environments has the potential to revolutionize various aspects of modern life, improving efficiency, reducing costs, and enhancing quality of life for individuals and communities alike. A smart environment refers to a physical world that is seamlessly integrated with a network of sensors, actuators, displays, and computational elements, embedded in everyday objects and interconnected through a continuous network. This network enables the collection, analysis, and processing of real-time data to create intelligent and responsive systems that can adapt to changing conditions and provide personalized experiences for users. Examples of smart environments include smart homes, smart cities, and smart factories, among others. [12]. In the context of a smart SC, this refers to a SC where each member of the process such as the retailer, producer, and distribution centers can interact and communicate with all in-store and in-transit products to form a complete self-sustaining holistic system. An SC becomes “smart” when all parts of the process can exchange data with one another and make decisions based on it. A smart contract consists of value, address, functions, and state. Smart contracts in the supply chain industry are designed to automate various processes and enforce predefined conditions without the need for intermediaries or centralized authorities. When integrated with blockchain technology, smart contracts can leverage the decentralization, security, and transparency of blockchain networks to create a more efficient and trustworthy supply chain ecosystem.

In a blockchain-based smart contract system, a transaction is taken as input and the relevant comparisons are made against predefined conditions. Once the conditions are met, the code is executed to produce a certain output. This process is carried out by the blockchain nodes, which work together to verify and validate the conditions, as well as to record the transaction on the blockchain ledger.

Because blockchain networks are decentralized and secure, the use of blockchain-based smart contracts can help to reduce the risk of fraud, errors, and disputes in the supply chain. Transactions are transparently recorded on the blockchain ledger, allowing all parties involved in the supply chain to have a real-time view of the transaction history and ensuring that records cannot be tampered with or manipulated.

Overall, the integration of blockchain technology with smart contracts in the supply chain industry has the potential to create a more efficient, secure, and transparent supply chain ecosystem, reducing costs, improving trust, and enhancing the overall customer experience. in a secure open environment [13].

V. SOLUTION FOR PACKAGE TRACEABILITY USING BLOCKCHAIN AND IOT

This section discusses a blockchain-based solution for traceability of packages, such as parcels, produce, or any other packaged items. The solution aims to provide a transparent and secure way to track the movement of the package throughout the supply chain, from the point of origin to the destination.

The solution is built using a combination of blockchain, smart contracts, and IoT technologies. Each package is equipped with an IoT device, which collects data such as temperature, humidity, and location, and sends it to the blockchain network. The data is then stored on the blockchain ledger, creating an immutable record of the package's journey.

Smart contracts are used to define the rules and conditions for the package's movement, such as temperature thresholds or delivery deadlines. When these conditions are met, the smart contract is automatically executed, triggering the next step in the supply chain process.

The blockchain network provides a transparent and secure way for all parties involved in the supply chain to access the package's data. This includes the package sender, recipient, carriers, and any other intermediaries involved in the package's journey. By providing real-time access to the package's data, the solution enables parties to quickly identify any issues or delays in the supply chain and take corrective action.

Overall, the blockchain-based solution for package traceability provides a reliable and transparent way to track the movement of packages throughout the supply chain, improving efficiency, reducing costs, and enhancing customer satisfaction.

The solution will use an IoT sensor attached to the package which will send signals to Sigfox Gateway. This data is being sent using UNB (ultra-narrow band) having bandwidth of 100 bps (Bits Per Second) and 600 bps [22]. The web application that we have developed will communicate with the Sigfox cloud gateway using a JSON API. This API allows the web application to send and receive data from the Sigfox cloud gateway in a structured format that can be easily processed and interpreted by both systems.

By using a JSON API, the web application can seamlessly integrate with the Sigfox cloud gateway, allowing for real-time data transfer and enabling the application to receive updates on the status and location of packages as they move through the supply chain.

The use of a JSON API also provides flexibility in the types of data that can be transferred between the two systems. For example, the web application can send specific requests to the Sigfox cloud gateway to retrieve data on package location, temperature, or any other relevant parameters, while also providing updates on package status and delivery.

Overall, the use of a JSON API allows for efficient and seamless communication between the web application and the Sigfox cloud gateway, enabling effective tracking and traceability of packages throughout the supply chain.

VI. CONCLUSION

In summary, while blockchain technology is rapidly evolving, it still has a long way to go before becoming an industry standard in supply chain (SC) operations. However, with increasing globalization and online transactions, the relevance of blockchain in SC is becoming more apparent. Blockchain's ability to integrate with other technologies, such as smart contracts, cloud, and IoT devices, makes it highly versatile and adaptable in the SC sector, providing benefits such as transparency and provenance. Many leading companies have already adopted blockchain technology in their systems, and the emergence of existing decentralized applications is a testament to its increasing popularity. This paper provides a detailed analysis of the characteristics of different blockchain networks and the latest asset tracking technologies for use in traceability in SC, and presents a prototype software architecture for traceability using the Solana blockchain and a Sigfox sensor. The prototype demonstrates the potential benefits of using blockchain in SC, but there are still limitations that need to be addressed, such as connectivity with other IoT networks like LoRaWAN. In the future, further research could lead to the development of a generic library that will allow integration with other blockchain networks, making it more accessible to a wider range of industries.

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