

# A Review On Blockchain Based Supply Chain Systems

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**Abstract** — Blockchain has offered solutions to many problems through its core principle of decentralization and distributed nature. Some of the fields in which these can be seen are Finance, Supply Chain, Healthcare, Real Estate etc. Among these, blockchain has transformed the functioning of the supply chain, increasing efficiency, transparency and security. Blockchain has allowed creation of an immutable track and trace system from sourcing of raw materials to the delivery of finished products. It has streamlined the administrative process leading to cost saving and faster processing time. Various solutions have been developed to tackle the problems faced in the supply chain industry solving one or multiple problems. This paper aims to assess the main solutions proposed and evaluate their advantages and disadvantages.

**Keywords**—*blockchain, supply chain, traceability systems, transparency, smart contracts, NFT*

## I. INTRODUCTION

Blockchain has brought about an unprecedented wave of applications and products. It has transformed the way we handle traceability in supply chain and product management. During our review, we have come across various implementations of these ideas. We describe some of these implementations, their architectures and limitations in proper detail and try to elaborate some of the ways we can use new breakthroughs in blockchain tech to improve the current systems.

To go further, we first describe the terms that have been frequently used in this review. Blockchain technology is a distributed, decentralized, and public digital ledger that is used to record transactions across many computers. It allows for secure, transparent, and tamper-resistant storage of information, making it an ideal tool for various industries such as finance, healthcare, and supply chain management. The blockchain consists of a network of nodes, each of which maintains a copy of the ledger, and transactions are validated and added to the ledger through a consensus mechanism. Once recorded, data on the blockchain cannot be altered, making it a highly secure and reliable form of data storage. Blockchain technology has the potential to revolutionize industries by enabling trust, transparency, and efficiency in processes that

traditionally rely on intermediaries or centralized authorities. While the technology has been around for a while, one of the first large-scale implementations of blockchain was the world's first cryptocurrency 'Bitcoin.' With this emerged more use cases for blockchain in various fields, one of which is Supply Chain Management.

Supply chain is the term that describes a group of entities involved in bringing a product from ground zero to a customer's hands, while generating profits for the business. Some of the problems faced by traditional supply chain implementations are opaque systems, inefficient information sharing, trust between involved parties and the difficulty in tracing products that have been through the supply chain.

Blockchain try to solve these problems through decentralization and distributed systems. By decentralization, blockchain technology eliminates the need for intermediaries, reducing the risk of data manipulation or corruption. This can help improve the efficiency and transparency of processes, while also increasing trust among stakeholders. Also, blockchain uses cryptography to secure transactions and data stored on the blockchain. By using advanced encryption techniques, blockchain technology ensures that data is protected from unauthorized access or manipulation. The distributed ledger system enables the tracking of products throughout the supply chain, providing visibility into each stage of the process. This can help improve accountability and reduce the risk of errors or delays, saving operational participants a lot of money and time.

The goal of this paper is to thoroughly review some of the implementations, while also exploring some newly developed technologies that can help develop more all-round solutions.

Section II defines important aspects about the idea, underlining exactly what problem is to be solved in context of supply chain, it's need and important terms associated with it. Section III goes describes each of the implementations that have been selected and reviewed to understand the currently utilized solutions, their methodology, advantages, disadvantages and what improvements are required in said solutions, according to the paper. Section IV goes a step further outlining where current solutions are limited and how

these can be classified for better understanding. Section V discusses various solutions that can be applied targeting the limitations extracted from above section.

## II. LITERATURE REVIEW

The literature review for this paper has been done with the goal of

- Understanding Supply chain management and what kind of problems exist in the current systems
- Understanding the latest blockchain-based solutions and implementations in the market and research paradigm

In order to solve a problem in a system, you must understand the system first, which is why this review first goes through papers that outline what a supply chain is, what it accomplishes for the industry, and the shortcomings faced in the practical applications.

[1] is a paper that discusses what makes a player with an integrated supply chain successful, and how the shortcomings faced can bring down an industry giant, while concluding what makes supply chains valuable and successful. Taking a leaf out of this paper, a case study on a supply chain situation involving Nokia, Ericsson and their microchip supplier Philips must be highlighted. An internal problem at factory level for Philips led to a failure in meeting the microchip inventory target for both companies, and the approach in handling this supply chain anomaly resulted in one company failing to meet consumer demands (Ericsson) while the other by default became the largest remaining industry giant (Nokia). These approaches by both companies are highlighted, with an emphasis on a certain principle that it highlights many more times and concludes to be a very important part of why supply chains need effective collaboration and how that adds value to companies.

This is the 3Ts that stand for

- a) Time,
- b) Trust and
- c) Transparency

Another term that comes up in supply chain related applications is 'traceability'. Traceability is another important factor that influences supply chain efficiency depending on the context in which it (Supply chain) is applied. At first glance, traceability and transparency seem interchangeable, something that is proved to be wrong by this [2] paper. Transparency is described as the shared understanding of product related information and access to said information without any noise, delay, loss or distortion. While traceability is described as the ability to access atomic level of information of anything that is a part of the supply chain.

### A. Implementation Review

A systematic review [3] about food traceability and blockchain, this paper gives insight into the supply chain details in the Fast-Moving Consumer Goods Industry and how traceability can be improved on a supply chain level. A total of 14 papers collected from various journals and resources have been reviewed. It iterates over the general ideas of the advantages using blockchain practically brings in each paper,

showing how traceability of foods and other consumer products can be managed. Another interesting notion highlighted by the review is the platforms used in these implementations, which includes platforms like Ethereum, one of the largest public blockchains in the world, Hyperledger Fabric, a very well-known blockchain applications framework that can be pertained to private blockchains, Hyperledger Sawtooth and a Multichain platform, which gives us an reference on which implementation methodologies can be differentiated on.

The papers analysed here forth show the current blockchain based solutions and implementations, the problems they solve and an overall comparison of some of these implementations

This paper implements a Traceability System for agricultural products, which uses both on-chain and off-chain data. A Blockchain plus Database approach is used to show and verify data about products like fruits and vegetables to customers. This is approach taken to overcome data load and privacy problems of the traceability system, with emphasis on multi chain [4]. The platform used in this case is Hyperledger Fabric.

A unique case of implementation, [5] discusses a solution for Chinese herbal medicines related supply chain processes. The intent is to bring better traceability and data integrity for building trust with the consumers about the product's authenticity. The system has three main components in a private blockchain for each of the department's handling certain processes like plantation, quality inspection, storage etc; a consortium blockchain for all the enterprises involved; and the IPFS or Inter-Planetary File System, where all the data related to the product is stored. The paper also establishes that the data fed to the system would mainly come from IoT based Sensors and current research is only based on manual data collection.

Elmay et. Al. [6] tackle the problem of shipping containers and cargo traceability in maritime industry. The paper lays out a smart contract based blockchain application architecture, defining each component in the implementation. NFTs are used to replace the paperwork required for transfer of ownership of cargo at port level transactions. Along with tracking, the application also enables auctioning of unclaimed containers. The application uses Ethereum as its blockchain platform, using smart contracts written in solidity.

[7] offers efficient product tracing in the pharmaceutical supply chain industry, using smart contracts and decentralized storage. The paper describes the complexity in the network of distinct businesses that are part of the overall supply chain. It puts forth the fact that 30% of pharma products sold in under-developed nations are counterfeits, thus emphasizing the need for drug traceability to prevent and reduce counterfeiting. It is understood that a private blockchain is used for demonstrating the various smart contract functions, with a detailed architecture outlined in the paper.

The table below summarizes the content related to each of the papers that have been defined above.

TABLE I. SUMMARY

| Paper                                                                                                           | Field of work                                            | Methodology                                                                                                  | Advantages                                                                                                | Disadvantages                                                                                                                              |
|-----------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| A Trusted Blockchain-Based Traceability System for Fruit and Vegetable Agricultural Products                    | Food and Consumables                                     | Hyperledger Fabric based blockchain network with an on chain + off chain storage structure                   | Better query time than on chain implementation, Increased transparency and trust                          | Initial cost of setup, partner on boarding                                                                                                 |
| Traceability System for Rare Chinese Herbal Medicines Based on Blockchain Structure                             | Rare materials logistics (Chinese Herbal Medicines)      | Combination of private and consortium blockchain, IPFS used for storage of hashes                            | Successful at tracing the product at every stage of supply chain lifecycle                                | Information vetted in the private blockchain only, enterprise level regulation applied on consortium blockchain only after sale of product |
| Using NFTs and Blockchain for Traceability and Auctioning of Shipping Containers and Cargo in Maritime Industry | Cargo transportation and management in maritime industry | Ethereum platform-based architecture, use of smart contracts and NFTs to define operations and data entities | Successfully applies supply chain operations along with functions for handling unclaimed cargo auctioning | All data from transactions done visible for anyone to see, increased transaction time during congestion                                    |
| Smart Contract System Architecture for Pharma Supply chain                                                      | Pharmaceuticals Industry                                 | Smart contract based pharmaceutical supply chain distribution, no particular platform targeted               | Enabling trusted and distributed traceability, generic, can be applied for any pharma-based supply chain  | Adopting into other supply chains can be complex                                                                                           |

### B. Limitations in current implementations

As with any implementation, some limitations come up in practical use cases. In this context, these limitations can be classified according to the type of blockchain platform used in the implementations. These types are:

- Public
- Private
- Consortium

Public blockchain platforms like Ethereum have been used in [6]. One fundamental problem that crops up pertains to the fact that all information uploaded on the ledger is visible not just to the supply chain participants, but also to anyone and everyone connected to the network. Which means any transaction done on the network will expose all data about it, including prices, locations, names, emails etc, something that [8] and [10] paper also shines light on. Another problem that is faced by public blockchains is higher transaction time, if the platform is unable to handle a larger number transactions, with too many users using the platform the time taken to complete one transaction increases significantly. Thus, the lack of private data transfer and increased transaction time in certain

conditions hinders the implementation for certain industry level supply chains.

Blockchain tools that let enterprise-level blockchain solutions come next as being used by some implementations. [4] uses this as an implementation standard. A clear disadvantage is the reduced decentralization due to only supply chain participants being allowed to join the network. But another more ergonomic disadvantage is the cost of setting up such a solution on a large scale, considering blockchain is used alongside IoT based solutions [11] like RFID sensors, GPS Sensors to track the actual products. Something medium or smaller enterprises may be unable to turn an ROI on.

Consortium blockchains have been used in conjunction with private blockchain for increased decentralization, but with a low number of transactions per second, scaling such an implementation becomes a challenge, although one of the implementations works around this by delegating some storage off chain [5]. With each implementation's limitations covered, we discuss the potential solution that can target these.

### III. PROPOSED SYSTEMS

We propose a few hypothetical systems in trying to solve some of the technological disadvantages understood in the implementations studied, some being improvements in the studied implementations while others are platform level solutions that target the limitations mentioned.

For most implementations, the nodes that are part of the decentralized network carry out different functions, along with storing a latest copy of the blockchain. The number of nodes in the network shows how decentralized said network is overall. Private Blockchains generally have a smaller number of participants as nodes, which implies less decentralization. This can be solved by using a private blockchain with separated representational and storage nodes, not letting number of participants define the extent to which an implementation is decentralized.

Another solution that is a development approach is to not target specific blockchain types and instead create smart contracts that can be deployed and used on any platform according to their supply chain needs. [7] has created such a generic plug and play system. It uses this principle to create a smart contract architecture that can be used by any pharmaceutical supply chain applications.

A public blockchain platform that allows participants to do transactions with private data is one such solution. Such a platform is already being developed under Polygon Foundation [9] by EY-Blockchain, called 'Nightfall V3'. The platform uses Zero Knowledge Proof, a concept from cryptography that is defined as: 'For a prover and a verifier, a prover can prove he or she knows certain piece of information without actually revealing said piece of information, to the verifier.' using zero-knowledge proof. The platform is especially designed with enterprise level needs in mind.

### IV. CONCLUSION

In the above sections, we highlighted important supply chain attributes like Trust, Transparency and Time that make a supply chain successful in its goal of adding value to a business and research on what can be improved in currently available systems. We then presented the various implementations of blockchain based supply chain systems,

and put forth their challenges, based on the type of blockchain technology used by these implementations. We also propose various solutions that target these limitations and build better blockchain solutions for the supply chain industry.

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