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## BLOCKCHAIN BASED SUPPLY CHAIN MANAGEMENT SYSTEM

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**Abstract:** *Blockchain technology has gained widespread acceptance and importance within the previous couple of years. Implemented in numerous areas of applications like social, legal industries, finance and supply chain networks. This technology assures immutability and integrity of information without the requirement of third party. In addition, blockchain technology could guarantee a transparent and decentralized transaction system in business industry. Handling an effective supply chain is not an easy task. For any business to be an effective one of the most important part is customer satisfaction. The customer needs more transparency, accurate traceability of the product, detailed information about the product. We explore how this technology can be used in the supply chain to make it more effective and suggest a blockchain-based supply chain management tool. To increase security, one of the most effective permissioned blockchain solutions is Hyperledger Fabric. In this, network participation is controlled by predefined rules. This feature makes this technology more effective than other technologies.*

**Keywords:** *Blockchain, Hyperledger Fabric, Docker composer, Docker, Smart contracts.*

### I INTRODUCTION

The management of the supply chain is focused on the needs of the consumers. It's all about providing the right amount of product in the right quantity for the right price. All this, in perfect timing and setting. In Supply chain, retailers, producers, shippers and customers are spread across multiple countries which requires careful coordination and management. Knowledge regarding an entity is not entirely available to those in the supply chain in conventional supply chain models, resulting in misleading reports and a lack of interoperability. Emails and printed documents provide some details, but since goods are difficult to track through the entire supply chain, they can't provide completely comprehensive visibility data. This also makes it almost impossible for a buyer to determine a product's true value and origin. New technologies are opening up exciting opportunities for change across the supply chain. Using blockchain in the

supply chain can enhance the efficiency and traceability as well as reduce operating costs.

The first blockchain implementation, Bitcoin, sparked widespread blockchain experimentation, especially in financial services. Large companies and start-ups are exploring applications of blockchain outside of the financial services sector as the technology gets popular. Many businesses are now working with blockchain technology to meet a variety of needs. Provenance, a supply chain transparency startup, recently completed a six-month pilot using blockchain to monitor responsible tuna sourcing in Indonesia. Monegraph, a 2014 start-up, uses blockchain to protect the usage and sharing rights of digital media like video clips or brand-sponsored content, as well as revenue sharing among media producers, publishers, and distributors. Skuchain creates blockchain-based B2B trade and supply chain finance products for the \$18 trillion global trade

finance industry, which includes consumers, sellers, logistics companies, banks, customs, and third parties, among others.

Companies may digitize physical items and create a decentralized, permanent archive of all transactions, enabling the end user to track assets from production to delivery or use, making end-to-end supply chain tracking more effective and reliable. This increased transparency in the supply chain gives both businesses and consumers more information. Both parties in the respective supply chain have access to the same information, potentially minimizing communication or distribution data errors. It is possible to spend less time validating data and more time delivering products and services, resulting in increased productivity, cost savings, or both. Public blockchains, federated or consortium blockchains, and proprietary blockchains are the three main types of blockchain networks. Hyperledger is a blockchain platform that aims to assist businesses in building private or permissioned blockchain networks in which multiple entities can share ownership and permission to run a node within the network. It is a distributed ledger technology that was created by IBM and Digital Asset in the beginning. It has a modular architecture and is made up of several different components. It's also a modular solution with a pluggable consensus model, but it currently only allows for agreed, voting-based consensus.

## II LITERATURE SURVEY

- The supply chain management system for dairy products was designed by Shivani Bhalerao, Siya Agarwal, Shruthi Borkar, Shruti Anekar, Nikita Kulkarni, and Sumedha Bhagvat. They've built a framework that's simple to understand and use for non-technical users. They built the app with react-native so that it could be used on both Android and iOS. They've gone with Hyperledger Composer for the server-side blockchain implementation. The project would bring transparency and security to the entire supply chain.[1]
- First, Guido Perboli, Stefano Musso, and Mariangela Rosano leverage the most recent digital strategy literature to create a conventional Blockchain technology use case design approach that isn't applicable to financial applications. Second, they present the results of a use case in fresh food delivery, highlighting the key aspects of the Blockchain solution implementation. The research looks at how the Blockchain can help reduce logistics costs and increase operations, as well as how it can help with science's complexities. [2]
- Xin Zhang, Pengcheng Sun, Jiping Xu, Xiaoyi Wang, Jiabin Yu, Zhiyao Zhao, and Yunfeng Dong proposed a new system architecture based on blockchain technology for the entire grain supply chain, as well

as a multimode storage structure that integrates chain storage. Real-world situations and application scenarios were used to test and verify this prototype framework. As a result, this framework is extremely important and serves as a benchmark for ensuring food quality and process traceability. [3]

- Miguel Caro, Muhammad Ali, Massimo Vecchio, and Raffaele Giaffreda present AgriBlockIoT, a blockchain-based traceability solution for agri-food that can seamlessly integrate IoT devices that generate and consume digital data along the chain. To effectively test AgriBlockIoT, they first defined a classic use-case within the provided vertical domain, namely from-farm-to-fork. They then designed and implemented such use-cases using two different blockchain implementations, Ethereum and Hyperledger Sawtooth, to achieve traceability. Finally, they analyzed and compared the performance of both deployments in terms of latency, CPU, and network use, highlighting their primary advantages and disadvantages. [4]
- Mark Soelman, Vasilios Andrikopoulos, Jorge Perez, Vasileios Theodosiadis, Karel Goense, and Arne Rutjes discuss how insecure endorsement policies can result in the ledger containing inauthentic data. To solve this issue, several methods for balancing integrity with restricted disclosure of sensitive information are proposed, with or without explicitly hosting a network peer. Furthermore, the concept of multi-tenancy in blockchain networks is being applied as a way to reduce the technical barrier to technology adoption. [5]

## III RELATED WORK

To control the supply chain more efficiently, different technologies have been used. Cloud-based supply chain management is by far the most common. Although cloud computing has many advantages for supply chain businesses, it also comes with its own set of risks. Businesses in every sector are concerned about cybersecurity. Your company data could be at risk if there is a data breach. Unauthorized use, whether deliberate or accidental. The sharing of resources among stakeholders and customers is referred to as the multi-tenancy problem. Since resources are vulnerable to leakage, this is the most serious risk. Multi-cloud problems arise from a variety of factors, including cloud setup and implementation, a lack of investment needed to ensure cloud compatibility, and the availability of more APIs, which means more entry points for hackers.

Over a previous couple of years, there has been an explosion in research and development activities around Blockchain technology, primarily within the financial technology industry. Indeed, its inherent capacity to deliver immutable

and tamper-proof records, combined with its potential to permit trust and reliability among untrusted peers, is just too enticing to stop this technology from remaining relegated to one vertical sector. As a result, Blockchain technology has already been dubbed a paradigm shift driver by many sectors outside of financial technology. In recent years, the use of certain IoT devices and developments in the supply chain management sector has received a lot of research interest. The combination of blockchain technology and modern supply chain management has become a popular trend in recent years. Nestle, IBM, and Walmart partnered on a pork supply chain management system based on the Hyperledger Fabric blockchain system.

#### IV PROPOSED WORK

Our framework shows how to bind to Hyperledger Fabric or the IBM Blockchain Platform to create an end-to-end blockchain application. We implement attribute-based access control, user management, and an Angular front-end UI to interact and query the blockchain ledger. This system guides the consumer through the process of purchasing, shipping, and enlisting the product for sale to the customer. Customers can track their orders all the way through the supply chain, giving them complete visibility. For instance, you can see a retailer receiving a shipment and then a customer logging into the application to see a record of when the shipment was ordered, shipped, and received. Finally, all orders in the system are accessible to a regulator, who ensures that proper procedures are followed. Confidentiality is needed in the supply chain because some customers may be offered lower prices than others. Other customers should not be able to see their rivals' prices in this situation. Hyperledger Fabric offers a way to enforce confidentiality at the chaincode layer using attribute-based access control since it is designed for a wide range of industry use-cases, including the supply chain. By registering and enrolling each user with a special attribute called "user type," this framework demonstrates how to implement such features. Admin, regulator, manufacturer, shipper, retailer, or consumer are all possible "user types". When a user successfully logs in and connects to a Hyperledger Fabric network instance, their "user type" grants them access to certain transactions that have been submitted to the network. For example, the regulator has access to all network transactions in order to efficiently inspect the network, while a retailer is only able to access assets and invoke transactions against assets which they are involved with.

##### A. Flow description:

1. To update and query the blockchain ledger and state, the user interacts with an Angular Web UI.

2. The user interface interacts with Node.js framework APIs on a backend server.
3. Fabric SDK APIs are called by the Node.js application server.
4. The Fabric SDK communicates with and submits transactions to a Hyperledger Fabric network or an IBM Blockchain Platform.

##### B. Software used:

1. Hyperledger Fabric: It is a modular blockchain framework that acts as a foundation for developing blockchain-based products, solutions, and applications. Plug-and-play modules are used in modular architecture to accommodate a wide range of use cases.
2. Docker: Docker helps you to package and run an application in a container, which is a loosely isolated environment. Because of the isolation and protection, you can run several containers on the same host at the same time. Containers are small and contain everything required to run an application, so you don't have to rely on what's already on the host.
3. Docker composer: Multiple containers can be run as a single service using Docker Compose.
4. IBM Blockchain Platform: It offers a fully managed and full-stack blockchain-as-a-service (BaaS) solution that enables you to deploy blockchain components in your preferred setting. Clients can use an offering that can be used from development to production to create, run, and expand their blockchain networks.
5. IBM Blockchain Platform Extension for VS Code: The IBM Blockchain Platform extension assists developers in creating, testing, and debugging smart contracts, connecting to Hyperledger Fabric environments, and developing blockchain-based applications.
6. Node.js: It is an open source, cross-platform JavaScript run-time environment that executes server-side JavaScript code.
7. Angular: It is a platform for building mobile and desktop web applications.

#### V METHODOLOGY

In our system, there are six user types: Admin, Retailer, Shipper, Producer, Customer, Regulator. Every new user has to get registered through admin. After successful registration user needs to enroll first before login. Users will need to enroll only once.

The retailer can see the list of placed orders with their details and status. The retailer will place the order of product by providing product ID, price, quantity, and producer ID. Order will be placed to that producer. The producer can see the list of received orders with their details and status. A producer

can accept an order or can reject an order. After accepting an order, the producer needs to assign a shipper. The producer will enter shipper details to assign shipment. The shipper can see a list of products with their details and status. Shipper will accept shipment, after accepting the shipment, the shipper needs to transport shipment and update the status of shipment from shipment created to shipment transit. The retailer will confirm that the shipment is received. The Status of the product will get updated after every step. After purchasing, customers can search and check the details of a particular product by entering the product ID. The regulator can see the order history of any product.

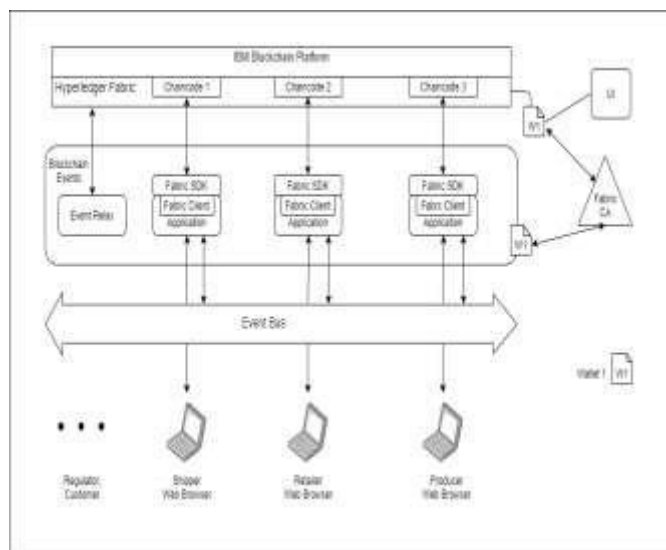


Figure 1 System Architecture

VI MATHEMATICAL MODEL

Let us consider S as system for supply chain management.

$$S - \{Q, \Sigma, \partial, q_0, F\}$$

Where Q – Finite number of states

$\Sigma$  - Finite set of tasks

$\partial - Q \times \Sigma \rightarrow Q$  is a function of state transition

$q_0$  – Initial state

F - Set of final state.

Q – {Login, Enroll, Logout, Admin, Retailer, Producer, Shipper, Customer, Regulator}

Let us represent above set as,

$$Q - \{q_0, q_1, q_2, q_3, q_4, q_5, q_7, q_8\}$$

$\Sigma$  – {Type - Admin, Type - Retailer, Type - Producer, Type - Shipper, Type - Customer, Type - Regulator, true, false,

create user, create order, delete order, accept order, assign shipper, create shipment, transport shipment, receive shipment, search product, order history, logout}

Let us represent above set as,

$$\Sigma - \{a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, r, s, t\}$$

$$F - \{q_2\}$$

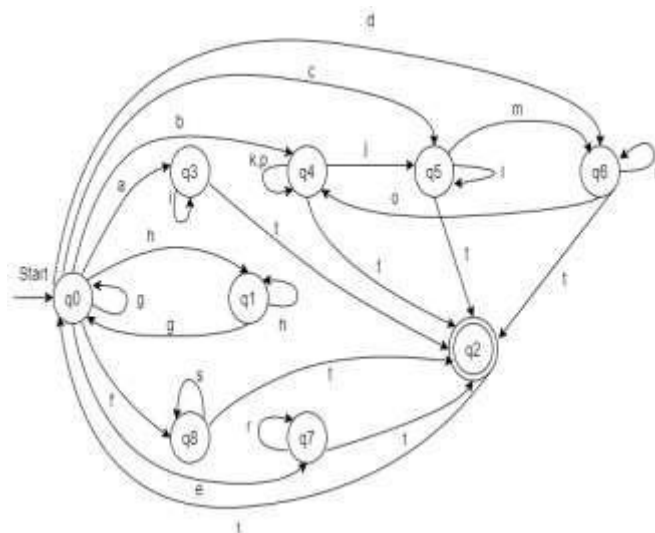


Figure 1 State Transition Diagram

VII RESULT ANALYSIS

Characteristics	Proposed System	Other Methods
Management structure	Independent companies in the supply chain, decentralised architecture	Centralized architecture leads to core companies
Regulatory scope	Via blockchain, the entire chain and life cycle of information can be managed.	Since managed by multiple companies, information exchange is not smooth
Storage mechanism	Distributed storage; data is stored in the blockchain's blocks, which are traceable and unalterable, and each node has complete data.	Centralized data storage; human data tampering is possible, supervision is difficult, and single-node failure is possible.
Industry Standard	Product information is stored in great detail, and security is ensured by smart contracts.	Product information is not thoroughly documented.

Table 1 Comparison of proposed system with other methods



Table 1 shows the advantages of this system over traditional supply chain systems. The proposed information management framework takes full advantage of blockchain's advantages, avoids the issue of relying on core enterprises to collect information, increases information supervision, and makes information exchange between all ties more accessible and transparent. The effect of stakeholders on information authenticity is minimized, and the phenomenon of artificial tampering is avoided, since blockchain information cannot be tampered with. Furthermore, using blockchain's consensus system, the "trust problem" between various ties in the conventional supply chain is solved. The supply chain's nodes are all connected to the same network, and each has full knowledge about the supply chain, effectively preventing tampering and data loss. This research looks at how blockchain technology can be used to improve the openness and accountability of data in the supply chain.

### VIII CONCLUSION AND FUTURE SCOPE

The adoption of Blockchain technology in the supply chain is a promising improvement that can help all of the various actors involved in the process. Blockchain helped us to overcome the problems in the supply chain like eliminating defective products. Throughout the supply chain, transparency and security are possible. Smart contracts will also help to eliminate the expensive delays and waste that currently exist as a result of manual paperwork collection.

Future work will focus on combining our approach with Business Process Modelling in order to direct Blockchain projects from concept to implementation.

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