

Blockchain and IoT Technologies for Sustainable Food Supply Chain Management and Traceability for SMEs

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ABSTRACT

Product Traceability has become very complicated in supply chain management particularly in the FMCG sector. Abundant growth of technology, security, and privacy is a prominent concern in the digital market however nowadays Blockchain technology is an alternate and plays a very crucial role in product traceability and security over the supply chain market. Blockchain has an innovative solution to store and maintain the data in a secure manner to ensure transparency and visibility between all stakeholders. Quality and Sustainability of the product is the key concern for the customer in blockchain-based supply chain management. The main problem in the existing solution is the centralized or distribution system that lacks the transparency of transaction details, and quality of the product. In which we have made a proposed solution is called decentralized system based on Ethereum Blockchain framework which will be useful to exhibit the awareness of the complete product supply from end to end product journey for each stakeholder involved in the supply chain industry. As the result of this study suggests that the entire context of the product journey, customer payment information, and tracking of the consignment are viewed by the customer through online QR code technology on each product in a sustainable food supply chain market using IoT features. Eventually, it allows the consumer to detect the source of the branded products empirically in the market

Keywords: supply chain management, Transparency, QR code, high innovative potential, decentralized system.

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1. INTRODUCTION

The main concept of the proposed solution is food Traceability. In the earlier days, it was very difficult to trace the food quality and details of the food items which are bought by the customers in the retail market. This problem statement has been resolved by contemporary information technologies in recent years. Finally, it creates awareness for the people to purchase good quality products for their health and benefits. My main motivation towards stepping into this proposed solution is customer trustworthiness to achieve the quality assurance factors across the supply chain stakeholders. Hence We have implemented a decentralized system for the supply chain model. These days traceability has become a new quality assurance for the food industries to maintain the best quality and safety. This new methodology enables the tracking of all the raw materials used in the food products by the particular industries. For example, there is a need for pickle production and the stakeholders who are involved in this production should take the permission of raw materials which they will use in the industrial work by the law.

Block-Chain is a technology that is mainly considered from the Fin-Tech market such as cryptocurrency, BITCOIN, etc in which area of the economy is getting increased in these

days. On the other side, the concept of blockchain is developing and it is capable of holding enormous potential growth for large- and small-scale industry purposes. This paper mainly aims to introduce the concept of blockchain which is used in performing supply chain usages in a secured and transparent way. Blockchain technology mainly ensures trust and security issues in the exchange of supply chain information over the networks. This paper is mainly describing the current and future possibilities of the applications using blockchain technology. The technology stack used the Ethereum blockchain framework.

The concept of traceability and all are based on the Internet of things (IOT) which involves real-time information about products through production and distribution from time to time. This technology also involves RFID hardware to identify the tracking of products through contactless radiofrequency waves which are used to transfer the data, the specialty of the technology is to identify every product with a unique code. In the current scenario, many human resources are involved in the production as a supplier, various regulators, and lakhs of end-users in which traceability data should be in the digital format and controlled by multiple stakeholders with different rules and regulations.[10] The digital format of the food supply model is very easier than non-digital practices and it may be even a little risky due to digital money transactions however the system ensures security then it will be much easier than any other solutions and time-saving method too.

This system will be helpful for small scale farmers very much because nowadays there are more fraudulent commitments in the production department of the food industries and the money is being only profitable for certain wealthy people and large-scale industries, however, to implement this system, each procedure which is available in the production stage can be viewed by all stakeholders even the farmer who had firstly supplied the raw materials for the manufactures.

2. LITERATURE REVIEW

In this section, we discussed and analyzed the topics related to the improvement of the food supply chain system. Food safety has become very prominent in recent times for commercial industries. Most of the systems till now are made centralized and these are not secured and only personalized between two persons. Hence, the solution has been introduced by blockchain technology for food supply chain systems to overcome this problem statement.

According to the [2] author, Dianhui Mao had deeply investigated safety and security, in this, he implemented a special focus on the food safeguards in the food supply chain for multiple stakeholders and was unable to handle the blockchain size as it becomes a growing concern issue which makes in the loss of database. An alternate view regarding his solution is to implement a highly protected and large size database while storing data in it. Author Khaled salah [4] had concentrated on the work of tracking and tracing items it showed everything regarding the order to the customers from end to end with full details along with proofs. The sad part of his idea could not be able to show the automated payments and proof of delivery. The author Affaf Shahid [1] had researched about the food supply chain and he had implemented digital transactions using smart contracts this is one of the highlights in his work it gets succeeded. The concept had failed to return and refund the food products which were delivered to the customers after the payment of the bill.

The author Hao Fu [3] had proved and trusted by customers and they had succeeded in the contract and dealing of the work done between the dealers and contractors but in some cases, his concept gets failed to manage business sensitivity regarding the relationship and contract issues in the research. Hence if give equal importance to every consumer, The author Prince Waqas Khan [7] succeeded to manage and handle the large numbers of users using the website server and he cannot store that many members in the database, and he failed to handle more complex business networks running in between the retailers and consumers.

According to author Michael Roger son said, [5] the quantitative analysis has an important role in the food supply chain, he mainly enhanced visibility to the whole team working under the production including customers and trust regarding cryptocurrencies. As a part of it, he was unable to handle provenance and guard against counterfeit goods. Author Niccolo Patelli [6] had researched on food supply chain and concluded some points regarding the product life cycle management and he had included certified details on the data which he collected from all the retailers, manufacturers, and distributors that can include the transaction details which can make the consumers trustworthy, but unfortunately, he was unable to control the cost of products which are provided with digital traceability because of the appliances and articles used to maintained to digital traceability.

3. RELATED WORK

Aim

The main aim of the study is to provide good quality food products with ample safety assurance for every person in society and the profit of farmers and retailers in the supply chain domain. The ultimate goal is to make people aware of food adulteration and create a transparent food supply chain model. In recent days, food wastage is being done because of inappropriate food packaging, food supply, and expiry dates reasons, so to make it transparent and bringing this concept of the food supply chain using contemporary secured technologies.

Food Traceability

Food traceability detects and captures all the basic information about goods, food, animal farming, etc. in the supply chain process. At all these stages in the process of production is needed food traceability process in the benefit of the product can be checked for quality according to industry standards and consumer needs[2]. It also aids in knowing up-to-date information on when and where the product is moved and made and what is the next process going to be done. Most of the food industries use traceability to improve the food supply chain process for tracing the food with safety[8] and quality aspects. It is a kind of technology tool to test the quality of food products and if there is less quality then it helps to improve the quality of the raw materials from suppliers.

RFID based authentication

Blockchain with the internet of things is made to bring the combination of perfect and holistic food supply chain case studies. The key objective of this study is to provide food without any adulteration for the people from rich to poor. The RFID is a hardware low-range transmission sensor used as a proof of object-based authentication using wireless protocols; this sensor will be used to sense the object at the physical level and transfer the data to the blockchain nodes at the logical level.[9] It is the real-time sensing element design for capturing complete information about the product and is also determines the real-time quality assurance check during product shipments.

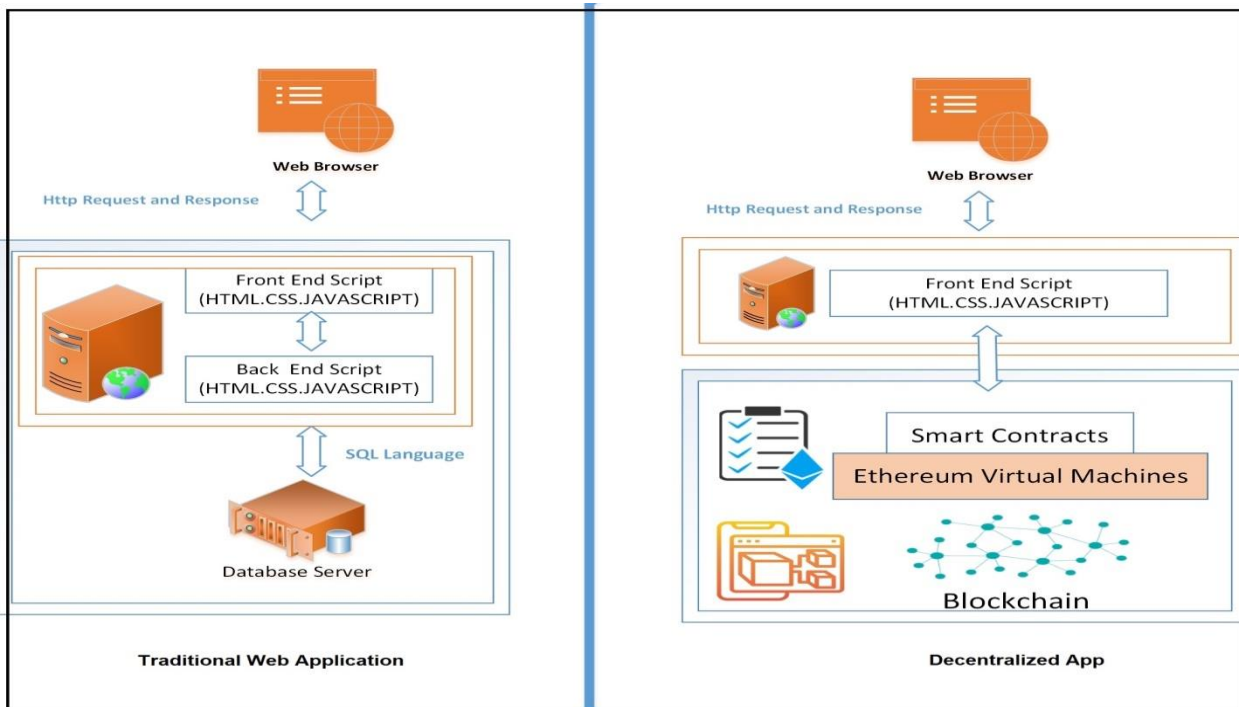
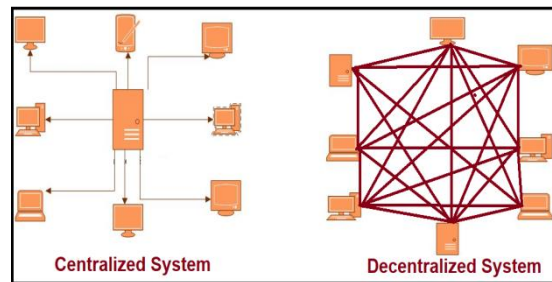


Figure 1

Blockchain technology Blockchain is a structured and decentralized system and developed to bring a practical solution for undefined problems in the field of security that are present in centralized and distributed systems. In this Technology, the pieces of information during the business transaction are stored in the form of blocks, and nodes that stored information are not in a centralized manner between the two peers instead it is decentralized as it can view everyone who is all involved in the production and supply chain process, where each block is connected to the next block and so on as it forms an in chain form so it called as blockchain. Blockchain can solve complicated cryptography, mathematics, and complex algorithms to attain the security features over the network, in this blockchain network once the information is stored into the blocks it is impossible to alter it is risky to work on this without valid consent from other peer group block miners in the network, hence being careful while entering the information in the form of a data blocks.



Smart Contracts

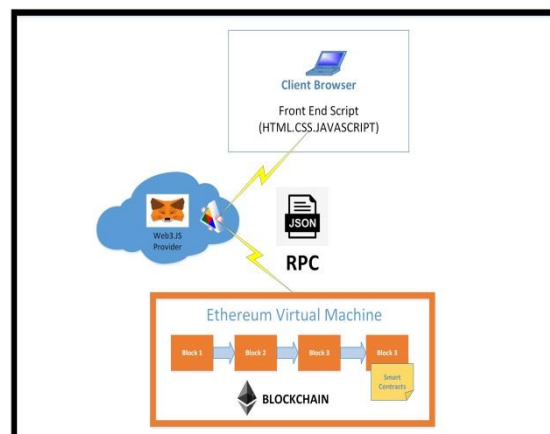
The smart contract is a trending notion in blockchain technology. The concept of Smart contracts takes care of convergence to executing the transaction over the entire blockchain networks through the virtual machine across the globe without any mediators. This is one of the main characteristics of blockchain technology. Ethereum is one of the open-source platforms to facilitate the opportunity to create the blocks which create the smart contract facilities between the encrypted networks.

Decentralized App (DApp)

DApp is a technology aka called Decentralized App over the Ethereum platform. This technology can write the user interface and experience logic for blockchain networks. The blocks are connected to the Ethereum network can send and receive the data to DApp application via web3.js intermediate software library. This library communicates the data to the convention web application such as HTML, CSS, JAVASCRIPT, PHP, JSP, ASP, and Perl, etc. eventually the encrypted data in which the blockchain network can visible on the user layer using the distributed web technologies.

WEB3.JS

Web3.js is a scripting language that helps to communicate between DApps and Smart contracts in Ethereum virtual machines via JSON RPC protocol over the internet. JSON is a lightweight protocol similar to XML over the HTML request and responses. Hence any type of electronic device can easily read the response and send the request and ensure the omnipresence of data communication.

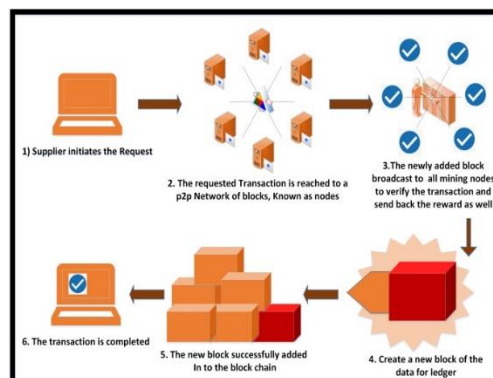


4. Design

To improve and modify the safety and stop wastage of food, we are bringing IoT combined with blockchain into the light to ensure the quality of food is visible for the consumers through digital data. The existing system has a centralized system in which only 2 members who are making transactions of food and money can only view the information between them but in the study, to implement the decentralized system in which the whole team working in the production and supply chain can view the entire product journey.[11] Basically, for every product, we can see the bar code printed on it which is used to bill the product in the supermarket, but for a change, to implement the unique QR code as a sensor on the backside of every product label so that the customer can scan the product QR code and get the complete details of it.

5. METHODOLOGY

Blockchain technology completely provides the alternate solution for existing distributed and centralized technology to perform security and privacy policies. Each transaction between the networks has a separate mechanism to attain trustworthiness among the stakeholders. Blockchain technology is classified into four types such as public permission, public permissionless, private permission, and private permissionless. All these types are working according to the need of versatile business scenarios. The intention is to develop successful smart contracts for the complex business requirement in the blockchain networks. Each block has a separate feature is called a miner. This miner's facility in each block is to verify the smart contract transaction across the blockchain network. Every block miners have to verify the security tokens for a single smart contract transaction and give the approval for the next level of the transaction. It is a classical process of peer-to-peer communication that helps to verify every transaction on the blockchain network.



5.1 Stakeholders involvement in the blockchain network

The supplier initiates the process to send the raw materials data such as certificate of origin, Batch numbers, and Cultivate information. Followed by the manufacturer plays a vital role and he will check the raw materials sent by the supplier whether the material is fresh and good in quality aspects. After that, the manufacture accepts the request sent by the supplier and he will add the product to his account and will send details like merchant ID, expiration date, number of packets, and production data, etc., this primary entry path for the next

Supply Chain Stages

1. Certificate of origin
2. Shipment Date
3. Certificate of origin
4. Lab Testing Date
5. Shipment Number
6. Shipment Date
7. Shipment Date
8. Shipment Date
9. Shipment Date

Blockchain Records

1. Certificate of origin
2. Shipment Date
3. Certificate of origin
4. Lab Testing Date
5. Shipment Number
6. Shipment Date
7. Shipment Date
8. Shipment Date
9. Shipment Date

Smart Contracts

1. Match Supplier, Order, Invoice, Shipment
2. Quality Check Specifications
3. Pay Supplier

4. Match Supplier, Order, Invoice, Shipment
5. Quality Check Specifications
6. Inventory Levels
7. Pay Supplier

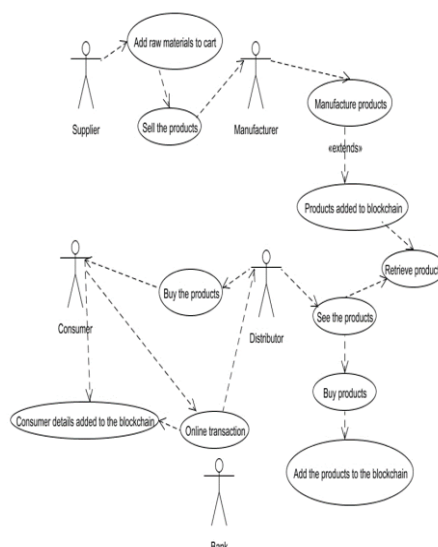
8. Match Supplier, Order, Invoice, Shipment
9. Inventory Levels
10. Pay Supplier

Finally, all the details will be added to blockchain verified by all miners in the network like transaction ID, Raw material details, product manufacturing details, Quality assurance Reports, etc., The consumer will check the products that they need from the supermarket store or e-commerce website and would buy the product using credit/debit cards or online banking through the bank credentials then transfer money through online then notification occurs as the order has been placed then consumer track the product through traceability technology and product details in the QR scan code printed uniquely on each product.

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graph TD
    Start(( )) --> Supplier[Supplier]
    Supplier --> AddRaw[Add raw materials to cart]
    AddRaw --> Manufacturer[Manufacturer]
    Manufacturer --> MfgProd[Manufacture products]
    MfgProd --> AddBlockchain[Add products to blockchain]
    AddBlockchain --> RetrieveBlockchain[Retrieve products from blockchain]
    RetrieveBlockchain --> AddDetails[Add details to the Blockchain]
    AddDetails --> OnlineTrans[Online transaction]
    OnlineTrans --> BuyProducts[Buy the products]
    BuyProducts --> Consumer[Consumer]
    Consumer --> AddBlockchain2[Add the products to blockchain]
    AddBlockchain2 --> Distributor[Distributor]
    Distributor --> BuyProducts2[Buy products]
    BuyProducts2 --> SellMaterials[Sell the materials]
    SellMaterials --> Manufacturer
  
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5.5 Use case Diagram



5.4 Algorithm

ETHASH is an algorithm on top of the PoW (Proof of Work) algorithm used in Ethereum based blockchain framework for block mining activities. It helps in authenticating hash functions and mathematical operations digitally. It is used for securing transaction hash code at a high level. Hashing is a concept of securing data in the key manner that is unless you open a key password you will not be able to open it. Solidity programming language helps to construct the Ethash algorithm to define the block mining activities. This algorithm propagates the concepts of decentralized consensus mechanisms in the blockchain cryptocurrency market.

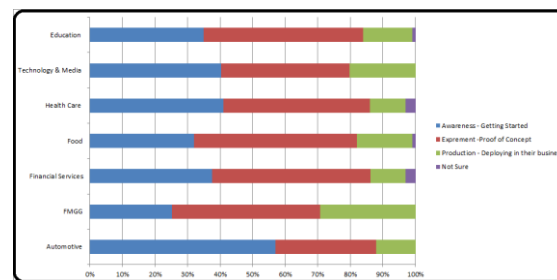
Platforms/ Segments	Ethereu m	Hype r Ledg er	R3 Cord a	Ripp le
Industry Focus	Cross Industry	Cross Indus try	Fin- Tech	Fin- Tech
Governan ce	Ethereu m Develope r	Linux Foun dation	R3 Con sorti um	Ripp le Labs
Ledger Type	Permiss ionless	Permi ssion ed	Per miss ione d	Per miss ione d
Cryptocur rency	ETH	NON E	NO NE	XRP
Consensu	ETHAS	Pluga	Plug	Voti

s	H PoW	ble	able	ng
Algorithm				

Various platforms are available based on the different types of blockchain networks. Each model gets different from various segments such as Industry focus, Governance Ledger Type, Cryptocurrency, Consensus Algorithm, and so on. Ethereum is one of the platforms which contains cross-industry implementation and permissionless ledger type based on the Ethash-PoW algorithm.

6. RESULT AND ANALYSIS

As per the study, the result has successfully occurred and in various analyses, it has been observed the process in different stages. The first stage is like growing and growers tend to sell the material to cooperatives again who will sell those to manufacturers who will check the quality and proceed to continue the process in which we will get the good food quality products. The results in this have many variations and risks in the food supply chain. Risks in these are there will be many periodic changes in exchange rate policies and instability in the customer demand are high rated risks and control in poor quality of food is low rated risk in the operations of the food supply chain. The performance of the food supply chain is good in many cases but it has major risks under the environmental conditions due to less supply of raw materials and in the condition of financial issues the process will slow down as per the production of raw materials.



Blockchain transformation by Industry

7. CONCLUSION AND FUTURE WORK

Food traceability has become the main concept of food safety discussions because in the present day the food is getting contaminated and people in society are suffering from different kinds of diseases. In this case, the first step we have to take is to test the food before using and trace the details of the food production. This tracing can be made using blockchain technology and the RFID technique. The solution has been implemented many changes from the existing system to the proposed system regarding food adulteration and it can be useful for the whole food industrial purpose.

QR scan code is the best thing in solution and Highlight of the project is Traceability concept which is unique for each project on the backside of the packet. The future work is to implement the rule for every supplier, manufacturer, distributor to get a government certificate provided by the law on quality assurance before coming into the market.

8. REFERENCES

1. Affaf Shahid, Blockchain-Based Agri-Food Supply Chain: A Complete Solution, IEEE Access, vol. 8, pp. 69230-69243, 2020.
2. Dianhui Mao, Innovative Blockchain-Based Approach for Sustainable and Credible Environment in Food Trade: A Case Study in Shandong Province, China. Sustainability, IJERPH, vol. 10, no. 9, pp. 2071-1050, 2018.
3. Hao Fu, Blockchain-based agri-food supply chain management: case study in China, IFAMA, vol. 23, no. 5, pp. 667-679, 2020.
4. Khaled salah, Blockchain for AI: Review and Open Research Challenges, IEEE Access, vol. 7, pp. 10127-10149, 2019.
5. Michael Roger son, Blockchain: case studies in food supply chain visibility, Emerald publishing limited, vol. 25, no. 5, pp. 1359-8546, 2020.
6. Niccolo Patelli, Blockchain technology and traceability in the agri food industry, JSF, vol. 85, no. 11, pp. 3670-3678, 2020.
7. Malla, S., M. J. . Meena, O. . Reddy. R, V. . Mahalakshmi, and A. . Balobaid. "A Study on Fish Classification Techniques Using Convolutional Neural Networks on Highly Challenged Underwater Images". International Journal on Recent and Innovation Trends in Computing and Communication, vol. 10, no. 4, Apr. 2022, pp. 01-09, doi:10.17762/ijritcc.v10i4.5524.
8. Prince Waqas Khan, A Blockchain-Based Secure Image Encryption Scheme for the Industrial Internet of Things, IJERPH, vol. 22, no. 2, pp. 1099-4300, 2020.
9. Aung, M.M., & Chang, Y.S., Traceability in a food supply chain: Safety and quality perspectives. Food Control. 2014, 39, 172-184.
10. J.Hermina, N. S. . Karpagam, P. . Deepika, D. S. . Jeslet, and D. Komarasamy, "A Novel Approach to Detect Social Distancing Among People in College Campus", Int J Intell Syst Appl Eng, vol. 10, no. 2, pp. 153–158, May 2022.
11. Abad, E., et al., RFID smart tag for traceability and cold chain monitoring of food: demonstration in an intercontinental fresh fish logistic chain. Journal of Food Engineering. 2009, 93(4), 394-399
12. Ghazaly, N. M. . (2022). Data Catalogue Approaches, Implementation and Adoption: A Study of Purpose of Data Catalogue. International Journal on Future Revolution in Computer Science & Communication Engineering, 8(1), 01–04. <https://doi.org/10.17762/ijfrcsce.v8i1.2063>
13. Folinas, D., Manikas, I., & Manos, B., Traceability data management for food chains. British Food Journal. 2006, 108(8), 622-633.
14. Mattoli, V., Mazzolai, B., Mondini, A., Zampolli, S., & Dario, P., Flexible tag datalogger for food logistics. Sensors and Actuators A: Physical. 2010, 162(2), 316-323.
15. Deepak Mathur, N. K. V. . (2022). Analysis & Prediction of Road Accident Data for NH-19/44. International Journal on Recent Technologies in Mechanical and Electrical Engineering, 9(2), 13–33. <https://doi.org/10.17762/ijrmee.v9i2.366>