Robust Food Supply Chain Traceability System based on HACCP using Federated Blockchain

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Abstract

In this fast growing world, everything needs to change and upgrade with the technology to survive in this rapidly changing environment. The Food Supply Chain system is one of them. In traditional supply chain management functions, it is hard to manage the flow of traceability information of products timely and effectively among upstream to downstream stakeholders. This gap in the flow of information and untrusted traceability of product causes to generate food contamination hazards and also increasing the network of modern FSC systems is still challenging to provide quality, privacy, and integrity of traceability mechanism. HACCP and Blockchain-based FSC provide various functions to enhance the FSC process such as traceability, transparency, security among all stakeholders. In these functions, some most important functions of the Food Supply Chain system are traceability, amount of data sharing, and privacy of data of products among stakeholders.

In this paper, we are going to provide an Enhanced Food Supply Chain Traceability system based on Federated Blockchain with HACCP using smart contracts. This model will manage by pre- selected leaders' nodes. These leaders' nodes have the right to control the action of middle nodes and lower nodes. The amount of data sharing can also be controlled by the leaders' nodes. So, any particular transaction is restricted to perform by middle and lower nodes because the Federated Blockchain is partially decentralized. This model overcomes the issue of privacy concern which remains unsolved by blockchain-based FSC and makes a better and enhanced Federated Blockchain-based FSC traceability system.

Keyword: Food supply chain, Federated blockchain, smart contract, traceability, HACCP, security

1 Introduction

In the industry line, the efficient work and smooth flow of the operations is a key strategy of every industry. Companies require reliable and real-time knowledge about production, on-time transportation of goods, to make correct supply chain decisions.

The supply chain-related systems play an important role in multiple factors of economic globalization. The supply chain-related system is used to minimize the complexity of the goods transportation cycle from origin to consumer, make industrial processes easier, and protect them from the evil habit intrusion and frauds in the system. But this system has some limitations when emerging decentralized ledger technology. However, mostly Present IoT-based traceability structures for food supply chains are based on centralized networks, but this creates a major space for unsolved issues and major concerns.

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a) Problems in the supply chain system

As increasing technology in business processes, the supply chain process becomes more complex due to evolving customer requirements, competitors, geographically separated locations, operation, and advancement in the new business processes like e-commerce. In recent past years, technology likes e-commerce and mobile gadgets change the daily lives of people regarding purchasing from home, this is an entirely different way of business. So there is so much complexity arises in the traditional supply chain process. There are many issues to serve customers or other stakeholders with valuable transparency of provenance of goods. The traditional supply chain fails to provide risk management for cost reduction and market requirement changes. We summarize some of the major issues in the current supply chain system.

1 Lack in traceability process

Traceability is the major problem in the supply chain regarding customer service and planning in business operation. When limited trust exists among the participants, traceability is hard to implement a centralized system in interconnected network.

2 Stakeholder distrust

In supply chain management, trust is the main factor to build an effective supply chain network. The supply chain system does not provide a trustworthy system itself to strengthen the supply chain network so that distrust appears among the stakeholders and to make it a trustworthy mechanism, stakeholders take third parties services to verify the process and transactions, which is cause to increase the operational cost and reduce the efficiency of the process.

3 Ambiguous transparency

Transparency is the major factor of any business, a transparent supply chain cause to increase the integrity of the product and build trust among stakeholders. But mostly supply chain networks provide minimum transparency. So, sometimes very important information lost when data share from one stakeholder to another.

4 Traditional methods of data sharing

Traditional supply chain networks shared their data among other organization through paper work. Most of the time these paper documents travel with the goods, inefficient data sharing and misguided paper document cause to reach late shipment at their final destination.

5 Compliance challenges

With the passage of time business regulatory standards become strict to provide safe services to the customers. In the current supply chain system, it is hard to gather information from many stakeholders and compiles with new standards.

A Block Chain Tecnology

Blockchain technology is used to enhance customer services and increases the efficiency of the operations. It maintains an immutable and secure data ledger that is transparent and equally updates the information to each node present throughout the network. It is a very reputed technology adopted by many areas of economic and social systems. A blockchain-based network relies on distributed ledger technology, in which every transaction record in a block and each block linked to another block with a secure hash value of the previous block, transactional data become immutable because every transaction made by any node must accept and validate by the network consensus and will be updated in every node's ledger in the network. It is a synchronized decentralized network, which works without any central authority to validate the transactions.

There are two types of blockchain technology with respect to its transparency, security and verifiability. In which one is permissionless and the other one is permissioned blockchain. In permissionless blockchain anyone can join anonymously, it is also called the public blockchain. In this blockchain low confidence and trust exist among the network user. To reduce the fear of an untested network, miners are used to validating the transactions in the network.

In permissioned blockchain network, every user identifiable throughout the network and is part of a central agreement called consensus in blockchain technology. It is also called a private blockchain. No new user adds to this group (group is the collection of individual nodes who stores and access amount of information) until he grabs the majority voting of the group members to agree that this new user can be added to this group. These blockchain networks provide trust among the users and it is not required, costly miners (miners can be described as, who records the blockchain transaction and receive cost of this work).

a) Key characteristics of block chain technology Blockchain technology has many unique characteristics such as verifiability, transparency, and immutability of distributed ledger, some of the most important are as follows"

1 Efficient transaction recording

Blockchain provides a secure way to recording the transaction in efficient manner.

2 Distributed governance

Blockchain the network does not rely on any third party involvement or centralized authority. It has a distributed database that provides security and transparency. In the blockchain, when any transaction performs, the ledger update to all the participant present in the blockchain network.

3 Decentralized architecture

Blockchain used decentralized architecture to update the ledger that is why data stored at all nodes, due to this central infrastructural point failure is not possible so that an efficient and

robust network generate which have reliability, availability, and quality of data and information.

4 Data transparency

Blockchain technology provides high transparency to all stakeholders. All the actions made are available to every node to see it. That is why no chance to make an illegal transaction.

5 Immutable data

It is not allowed to change in any transaction which has already made and verifies by the consensus method of the network and has stored in the block.

6 Traceability

Traceability of the supply chain ensures environmental protection as we as backtracking of products demonstrated by a particular business case. Blockchain has record bulk of transaction data and keeps them in a network and the system also those transaction records are shared peer to peer to all the connected systems.

7 Enhanced data security

Blockchain technology provides a strong feature of security by using digital signature algorithms and cryptography. it ensures the security of data and builds confidence throughout the supply chain process. All data, that maintained in a blockchain relies on predefined consensus and required permission of the majority of network nodes present in the network. This public ledger is unchangeable in nature and provides audit-ability of all transactions performed. Thus the blockchain has the properties to enable decentralized traceability systems, and show all the steps when the transaction occurs in a supply chain.

a) Federated Block chain, a Future of Block chain.
A consortium, Federated and private blockchain are way similar in nature. In private or a permissioned blockchain every node has no access to make any functional behavior even if the node is authenticating the system. Only one person or a leader has determined permission to do anything in the system. This kind of blockchain is ideal for use by businesses that also have dealings with each other.

In Federated blockchain, only a few defined nodes are granted power. These blockchains are simpler and more elastic. A federated blockchain allows greater improvement and flexibility in the structure of blockchain systems. Organizations will now share information more easily and with less hesitation. Federated blockchain is built for particular groups or individuals. The assumption that unknown people are not permitted on the network, which eliminates the probability of 51 percent of peers [16].

Many of the industry claim that the federated blockchain provides higher speed, scalability, efficiency and overcomes

fraud, information breaching problems. The federated blockchain also has a great way to use

in the future, but the fact is that having just one kind of blockchain is not a wise idea, because each of these blockchains may offer more benefits depending upon the need and use in the industry they are used in.

8 Hyper ledger fabric

It is a private blockchain network which is open source and makes for enterprise applications. It was made up of Linux based foundation. It provides many features, like a public ledger, smart contract engines, and consensus protocols. These multi-functional features made up this to adopt widely in many business applications such as finance insurance supply chain health care and human resources.

B Smart Contracts

A smart contract is the set of actions that specify digitally with defined protocols. Smart contract term firstly proposed by Nick Szabo.This concept of smart contract introduced in the Etherium blockchain network to provide verification and to improve contract performance. Before any transaction made in blockchain, the set of the contract defines the condition, obligation, rights, and concept between stakeholders. Set of predefine promises or contracts are stored and shared through- out the network and access to all node present in the network. Every transaction will perform under the net of a defined smart contract. Due to this more trust in the network developed which cause a reduction of risk, error, and fraud. Some of the smart contract benefits are:

1 Cost-saving

It cost saving due to reducing the time of processes and eliminate the intermediaries in the network.

2 Accurate:

It provides accurate and efficient mechanism of information storage through all agreement and defines conditions recorded in terms of computer code.

3 Speedy

It provides robust and efficient speed of transaction completion when define conditions are met with the contract.

4 Secure

Smart contracts are stored in the distributed ledger using an encryption mechanism to provide more security and distribute it to all nodes.

C Internet of Things (IOT)

Internet of things (IoT) is one of the popular technologies nowadays, it helps many industries to make their work easier. IoT is a device that is interconnected with digital objects with processes

and in the environment. You can gather knowledge, evaluate it, and take an intervention to support someone with a specific task or learn from a system by a unique digital identifier. These works are done without a human to human interaction and without a human to computer. Many of the researchers and developers are trying to implement many of the systems by adopting an IoT technology like RFID, and wireless network sensors or some open-source devices to monitor the real data related to the conditions in transporting of information and data.

1 IoT with digital Identifiers (RFID)

The digital Identifiers like RFID (Radio-Frequency Identifi- cation) tags, GPS, or a bar code. By these tags, assets are easily tracked and manageable. Many of the RFID systems are used in food-related companies to tracing food in whole supply chain management. It gives information about the producer, retailer, wholesaler, and consumer to the relevant management timely and effectively. This technology-related system is integrated with the supply chain systems to manage traceability.

D Hazard Analysis And Critrol Points (HAC- CAP)

The HACCP (Hazard analysis and critical control points) HACCP focused on risk control and avoidance, associated with food health. It easily connects with organization management like supply chain management (SCM) and food safety assurance. Fotopoulos et al. [19] have a literature review on food safety insurance schemes and the essential factors that influence the implementation of HACCP were reported. They reviewed 31 experiments in their study and found 32 variables that may influence the application of HACCP. By implementing HACCP in FSC with using (IoT), monitoring and traceability become much easy as compared with the traditional systems. HACCP method provides more efficiency and protection to all supply chain members and their related work.

In this section, we show an overview of the complete paper. In the first section, we highlight the overview of the technologies which is used in this paper or model. In the second problem-solving section, we provide number of research papers related to supply chain traceability systems with blockchain. We also proposed a food supply chain model that is beneficial in the entire factor when we use the food supply chain with blockchain for traceability.

Furthermore, our proposed model related to HACCP with Fed- erated blockchain using IoT digital signature (RFID) for trace- ability solution for food supply chain management (FSCM).

2 Releted Work

In this modern era the supply chain-related process is more complex. So, to overcome this complexity many of the researchers and developers use blockchain technology to improve traceability, business model and goals, transform relationships, and enhance the performance of business activities.

In this section, we provide the focus path of research, regarding integrating the blockchain with a supply chain to slow down the complexity of the above factors. Furthermore, many of the

distinguished research articles and proposed models are selected and present below:

Supply chain provides various functions to enhance the business process such as traceability transparency security, among all stakeholders. Especially, in safety, a sensitive sector likes food, medicine. This lack of information flow and no trusted traceability of products cause to generate food contamination hazards, also increasing network of modern food supply chain (FSC) system is still a challenging to provide quality and integrity of traceability mechanism. So this paper provides an automated traceability system of food supply chain (FSC).

The food contamination scandals are a real hazard for public health. The food Supply chain helps to mitigate this issue but it has certain limitations that not fully resolve this issue.

This paper, describe the issues which is relevant to the implementation of blockchain technology in the FSC and analyze its opportunities to increase the safety of food and its waste reduction. To overcome this issue the retail giant Wal- Mart integrates a blockchain-based supply chain to make food safety easier, traceable timely effective, and transparent[1]. Due to this product visibility throughout the network is very difficult and traceability compromise. So, traditional methods of data sharing in the business process are very costly and unacceptable as compared to innovative supply-chain management. In paper [3], blockchain technology in supply chain functions to enhance their functions, like traceability, transparency, and integrity of the business process and discuss current situations, key features of blockchain, security, and challenges of deployment blockchain technology with the supply chain [3]. This paper proposed the COC (supply chain in the blockchain), the supply chain management system based on the hybrid DLT. It is a two-step block construction with a better model mechanism of security and performance and unauthorized access [4]. In paper [5] the researcher studies many of the past papers and identify that many authors and the projects have been done to improve the transparency, traceability, and other factors throughout the supply chain from suppliers. Information and Communication Technologies (ICT) based supply chain traceability (SCT) solutions have been implemented. GLOB- ID project using a cloud-based centralized system to merge legacy business information systems and increase SCT [5].In paper [7] the researcher analysis and supports the significance of this particular issue by addressing this topic's urgent needs in this authoritative journal. So, this paper provides the focus path to the OSCM researchers regarding integrating the blockchain. Furthermore, the twelve distinguished research article is selected and defined [7]. Nowadays, new technology is evolving day by day so the blockchain is one of them. But, this technology has some defective properties like scalability when we face a bulk amount of data in the real world. In paper [8] the researcher develops a food supply chain traceability network, based on HACCP (Hazard Identification and Essential Control Points), blockchain, and the Internet of Things, which will include an information network of accessibility, accountability, equality, efficiency, and protection for all the supply chain users also introduce a new concept BigchainDB (a database who offering a decentralization integrity and allow a large scale applications and many variety for supply chain) to fill the gap

in the decentralized systems at scale [8]. It seems that supply chains facing challenges in information sharing and trust. The main purpose of this research is to increase trust among all agricultural industries by using decentralized technology that is not dependent on trust [13].

At the above, we thoroughly discussed various functions of the food supply chain like safety, security, transparency, traceability mechanism, and authentication of traceability function by integrating blockchain technology. Although we have found many benefits of blockchain integration in the food supply chain. But some issues still need to work on it. Like safety and security of food, enhanced traceability mechanism which ensures to control, manage, prevent, mitigate, and contingency plan for food products from production to consumers hand in any means. Another issue that arises in the food supply chain due to the integration of blockchain technology is immutability and decentralized nature. Due to this nature, blockchain updates the ledger of the transaction to all nodes of the network. So, there are some food companies that do not want to share all the data and information through the network, somehow this information can be harmful to their goods or products. Competitors and other evil habits can use this information to fulfilling their unethical ways of benefits and for fraud.

HACCP is associated with food health and safety. It easily connects with the organization management system for food safety assurance. HACCP is a systematic approach to identify the hazards related to food safety and ensure to all the authorities, stakeholders, and customers about the quality work which is done in the food supply process. This assurance comes from the control point of the HACCAP process. There are many control points in the HACCP for safety and to mitigate the risk factors in the food supply process. The control points are varying from food to food, as per food nature, the control points and monitoring plan changed. Because of this HACCP mechanism, the traceability of the system is far easier than before. After every event or process, the documentation and the data are updated in the system. So, in the end, the organization has a complete traceability record related to the current food process also, there are many types of research list which present the idea of HACCP with different technologies to make the traceability better and make the flow of the process fast to get effective output.

To overcome these issues we present a model in which we has use HACCP food safety management system with integration of federated blockchain using IoT (RFID) technology to enhance and improve the food safety mechanism throughout the network with greater transparency by providing leading and controlling rights of leader nodes of the federated blockchain network. Also remove the access of unwanted persons, who can capture important information unethically by using traditional blockchain technology. All of the data flow maintain and record by using IoT (RFID) technology.

3 Methodology

The safety of food and its reliability becomes a major problem in the world nowadays, due to increasing various ways of serving food to the customers. There are many intermediate stakeholders includes in the food supply chain, so that the FSC network becomes longer. This huge FSC network cause to arise many problems. Such as food fraud, illegal production of food, food contamination, that cause compromises people's health and loss of food industry. It also arises many technical issues, like transparent traceability of food and trustless environment among stakeholders, etc. food regulatory authorities, government, and concern department work a lot to overcome these issues. However, in this regard, we are going to contribute our methodology to solve these food safety and traceability issues.

In our system, we adopt Federated blockchain technology in the food supply chain system which provides some customized features to the user as their requirement or condition. Actually, a well-known use of blockchain technology is for digital currency transactions, which required a more transparent and detailed flow of information among the nodes of the network. But when block chain technology (BCT) integrates with the food supply chain, it makes the food supply chain transparently traceable from origin to customers with a complete flow of information. Somehow it is beneficial to make the FSC, traceable, transparent and trustworthy, among the nodes of the network, due to immutable distributed ledger update. But, besides this when BCT adopted by food industries, some privacy issues arises in FSC, because there is some private information that needs to hide from the other nodes present in the network. This private information can be used for fraud and competitors can be used this information to harm the reputation of the food companies. So, our methodology overcomes these issues by providing a Federated blockchain-based food supply chain system, In the Federated blockchain, Control is given only to few predetermined nodes. So, any particular transaction can make be restricted to non-leaders nodes.

Federated blockchain is partially decentralized. The consensus process is controlled by a pre-selected set of nodes in the network. These blockchains are faster and more scalable. Federated blockchain provides more transparent, trustworthy traceable information flow among the stakeholders. It provides the rights to the pre-selected set of nodes to customize the information regarding the federated member's need and they also customize intermediate stakeholder's appearance in the network.

Therefore, we divide our federated blockchain-based food traceability system into three streams. In which, 1st is Upstream which contains regulators, 2nd is Middle- stream which contains intermediate stakeholders and 3rd is Downstream which contains end-users. These streams build three pillars of federated members according to their control, rights, and usage. In Upstream, regulators are declared as leader nodes or full nodes, they can be food safety organizations. Leader nodes have complete rights to access blockchain information. All the information from origin to costumers is visible and traceable for them. They can manage and control, right of access of intermediate stakeholders and end-users, they can set different smart contracts for different types of intermediate stakeholders in the FSC network. They can insert data, search data, query data, and retrieve data at any time or any point from the blockchain. In the Middle- stream, intermediate stakeholders or middle participants are middle nodes, they can be suppliers, wholesalers or retailers, etc. Middle nodes have limited rights to access FSC information from the federated blockchain. Only one step above and one step down information are visible and traceable for them such as, where they got material and where they send after. They can insert data and queries of data from the FSC blockchain network. In Downstream, end-users are lower nodes, they can costumers. Lower nodes have only rights to get the query of data of food product from the FSC blockchain, regarding they bought from the retailer.

To select federated leader nodes of the FSC blockchain. We use PBFT to leader's election in the system among all the members in the blockchain. Elected nodes (Regulators) become registered leader nodes and get rights to login to the system as a leader or full node. They have the right to make different types of protocols and smart contracts for intermediate stakeholders

or end-user to access information from the FSC blocks chain. They have the right to get in or out of any intermediate federated members.

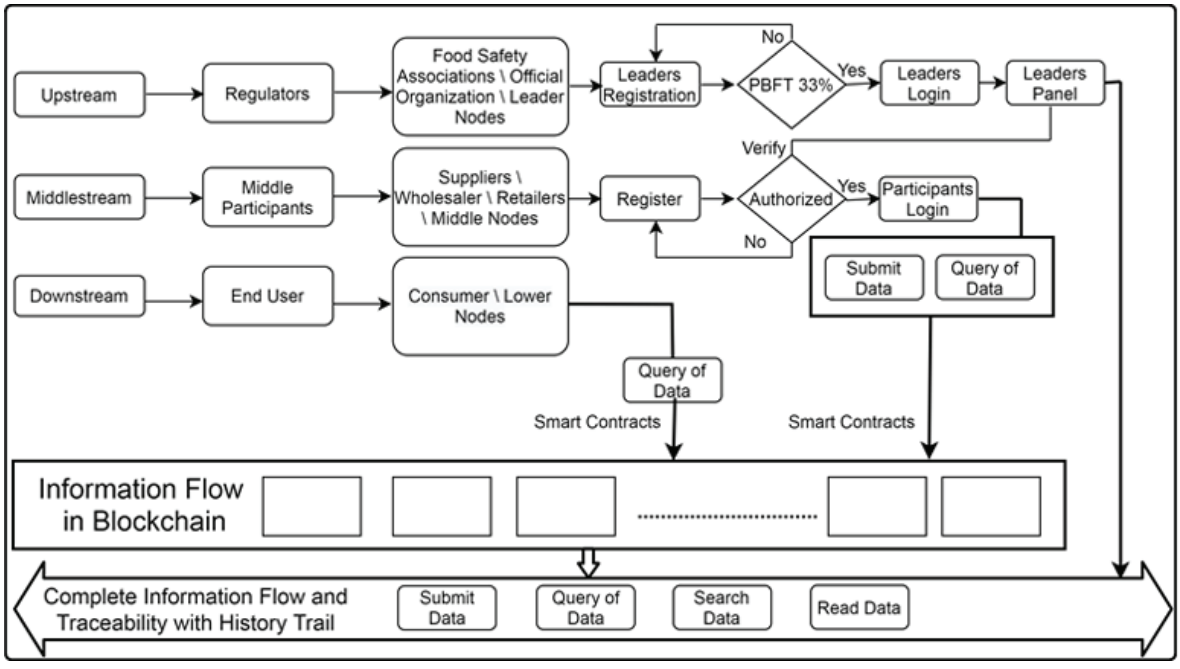

Figure 1: Federated Blockchain Based Food Supply Chain System

On the other hand, Federated intermediate stakeholders can register themselves in the system only when they authorized by the leader nodes or smart contracts which they set for authorization. If they authorized by the leader nodes, they have access to login in the system with limited rights. Access rights were assigned by smart contracts and the smart contracts set by the leader nodes with consensus. The registration, login, and access records store in the blockchain as proof. Middle nodes can register themselves with the permission of leader's nodes, they have the right to submit data regarding food information and get queries from previous data relevant to it by invoking smart contracts. The information they submit will be verified by all participants present in the network. There is no need for registration of lower nodes or customers. Customers have only the rights to access blockchain information for the query of data regarding they bought from the retailer. There are many smart contracts set for the query of data, insertion of data, and search for data to the regulators, intermediate stakeholders, and customers. So, in our Federated blockchain-based food supply chain system, we declare full nodes and medium nodes on the behalf of right, access, and control in the network. Lower node is not a part of this, because they do not have any kind of rights and control. Due to the full node, regulators have the right to see all information flow in the food supply chain without fear of privacy concerns regarding business competitors. Due to medium nodes, intermediate stakeholders stores and see their own information. The reason for setting full node and medium node in the FSC, that if regulators are the only nodes to insert data in the FCS can tamper with the original data and that information can be trustless for the intermediate stakeholders. So, to make transparent traceability mechanisms in FSC, Intermediate stakeholders or medium nodes have the right to store their own food information.

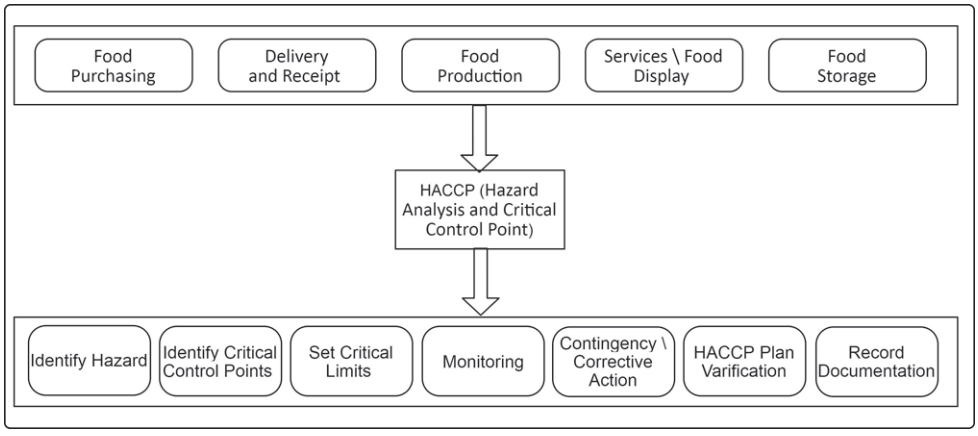

Figure 2: HACCP Based Food Supply Chain System

After proposed our Federated blockchain-based food supply chain system methodology, we can say that, the information visibility or data hiding rights, and controlled access of authorized members, regulators can achieve information privacy and controlled mechanism of transactions. Federated blockchain-based FSC minimizes the fear of theft of valuable information by bad cops and competitors. Our Federated blockchain-based food supply chain system provides effective information flow, customized transparent traceability, security of data, and trustworthy relation among stakeholders. When the federated blockchain mechanism is integrated with the HACCP so, the flow of the work goes more appropriate, secure, and traceable.

In the initial stage for the organization when the product or food is in the process of purchasing, the quantity, detail of the seller, detail of the receiver (this receiver is the part of the system and can authenticate by the RFID and insure by

the federated blockchain mechanism), detail of food before purchasing the food, is traced in the system and update the profile of the food product and the user, also all the product which are going to part of the system is assigned RFID tags to get more updates from time to time for further process.

The purchasing receipt is also updated in the system with a relevant receiver profile to ensure that there is no mishap or fraud in between this process. All this process is managed by the head of the sale and this managed by the main leader of the system who have a control of everything. By this surety, the further process flow moves to the next step. In food production and all the products are added to a system as a new product. Unique product information is added to the profile.

After that, the food service is initiated to check by the management to ensure the quality of the food, that which product should display or discard. The profile of the management is updated when task done by unique RFID tags by checking to the main lead head. The knowledge of purchased goods will be accessed automatically by setting up the appropriate IoT infrastructure in the warehousing center. Whereas, the product's real-time storage statistics, including amount, type, temperature, and the storage period, can be monitored by monitoring types of equipment and can track both, the product profile and the tag with wireless sensors. Inventory

information can be check by the lead in the system by the RFID. In order to prevent waste and spoilage, managers may agree on the basis of the specific details for which items will be given priority to quickly transfer out of storage.

In between the mechanism from the production to storage, there are many processes is going through to check the hazard of the food product. First check the nature of the food product to determine that what can go wrong in the process. Then ensure by the critical control points CCPs to identify key points where something can go wrong and its related control to mitigate these points. All the mechanism is update time to time in a product and management profiles which are interlink of the related tasks. Also, the main lead provides a manageable direction to the below management. Then, taking controls at CCPs to stop problems establish management in monitoring this process.

By this monitoring, the real-time sensor values are updated in the product profiles. If any harm is identified so take correct actions on the basis of the specific details. These controls and problem-solving strategies ensure and prove the HACCP Program works in the system. At last, all the basic information from start to end is reported as a document.RFID can use for the basic information when any of the users purchase that food product. This is done because of the federated blockchain that can maintain all the supply chain data fully audit-able. However, users can also get the detail of the product by this traceability system.

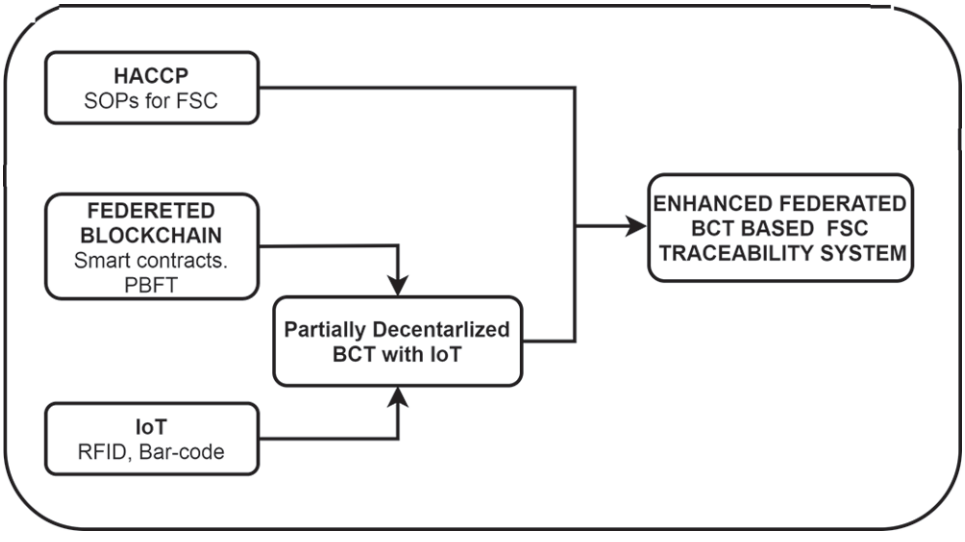

Figure 3: Enhanced HACCP Using Federeted BCT Based FCS Traceabilty System

4 RESULTS

We have derived different abstract results as per other mentioned/listed/referenced papers from our proposed method with the comparison of traditional blockchain-based food supply chain system and HACCP based food supply chain system. The comparison table relies on many characteristics that are used to enhance the functionality and performance of the food supply chain system.

In our flowchart based model, the federated blockchain-based FSC model is comparatively enhanced and provides better features to make the food supply chain system traceable and reliable. we set different parameters like (high, medium, low) to check the effectiveness of our federated blockchain-based food supply chain model from other models.

A comparison table of our federated blockchain-based FSC model with the traditional blockchain FSC model is as under:

Performance Criteria	Performance Variables	Traditional HACCP with FSC	Block chain based FSC	Proposed system (Federated BC with HACCAP) For FSC
Trust	Accountability Immutability Verifiability	Medium Could be tampered Medium	High Nearly Impossible High	High Hard to tampered High
Trust Model	Trusted, Semi-trusted , Un-trusted	Semi-trusted	Trusted	Semi-trusted
Efficiency	Cost Speed Energy consumption Technology	Medium Cost Low Low Energy consumption Traditional Equipments	High Cost High High Energy consumption BCT + IoT	High Cost Very High High Energy consumption BCT + IoT
Access Permission	Read permission Write permission	Public	Private / Restricted	Semi - Private / Selected Nodes
Responsiveness	Customer complaints Response time	Medium Low	Low High	Low Very High
Traceability	Real time Food Tracking	Weak \ Slow Traceability	Strong \ Fast Traceability	Strong \ Fast Traceability
Consensus Mechanism	Poof of Stake \ PBFT Proof of authority Smart Contract	HACCP SOPs	Poof of Stake Proof of authority	PBFT \ Smart Contracts
Food quality	Process quality Product quality	Medium Medium	High High	Very High Very High
Context	Data transparency Security privacy	Low Low Low	High High Low	High High High
Safety	High Safety / Low Safety	Medium	High	Very High
Authority	Centralized / Decentralized	Centralized	Decentralized	Partial Decentralized
Automation	Automated / Semi-Automated	Semi-Automated	Digital Automated	Digital Automated
BFT Tolerance	<=33%	No	No	Yes
Participants	Permissioned / Permissionless	Anonymous	Identified / Trusted	Authorized by Leaders Nodes

Figure 4: Performance Comparison Table of the proposed block chain based FSC traceability model [6],[8],[9].

we observed that our flowchart based model resolves those issues who create hurdles to the adaption of blockchain in the food supply chain with respect to privacy relevant issues which are considered a major hurdle to integrate blockchain in the food traceability system.

5. Conclusion

In this paper we conclude, regarding the food supply chain system. There are many challenging issues which makes difficult to adaption of block chain in food supply chain. For instance many of the suppliers, manufactures coordinate and collaborate with big network of stake holders,

which involve directly or indirectly in FSC. Because of this, it is hard to update information in real-time, also it is hard to sustain confidentiality, transparency and the traceability of FSC. After integrating block chain technology in FSC many of these issues has been resolve but one of the major still remain to solve which is amount of data sharing or privacy concern. Many of the companies or stake holders wants to hide un- relevant information and don't want to share core private information with other stake holders but block chain based FSC failed to overcome with this issue. So, In view of this, we proposed a new partially decentralized FSC traceability model by enables the federated block chain technologies, HACCAP and integration of IoT. Moreover, we demonstrate the working of HACCAP system which give to the real-time information of food with supply chain also, in our Federated block chain based FSC model, full node access and authorization control in the hand of few predetermined nodes. Selection of full leaders nodes by PBFT. These nodes have rights to control action of half or middle nodes and lower nodes. The amount of data sharing can also be controlled by the leader's nodes. So, any particular transaction is restricted to certain nodes because federated block chain is partially decentralized.

Our system improved the traceability, efficiency, transparency, privacy and trust between the involved nodes like stakeholders. Our model highlights the food fraud, illegal production of food, food contamination, which cause to compromises people's health and loss of food industry. By using this digital automated structure of our system. We will able to send and retrieve the confidential information like transactions with real-time environment and partially distributed way also, the main federated node can continuously monitor the goods and transaction digitally. By using this system structure it's significantly reduce the complexity of the FSC system and build the customer confidence of the product.

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