Blockchain based Smart Model for Agricultural Food Supply Chain

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***Abstract*—Ensuring food safety requires to fully monitor the overall process of handling food, preparation as well as storage of food in such a way that it reduces the risk of people getting sick due to undue cleanliness or any mismanagement in the overall process. Smart agricultural includes an efficient, clean and safe food supply chain system that can tackle these issues more smartly than that of existing system. Agricultural food supply chain denotes the mechanism explaining how the farm food comes to our tables. The research presents a smart model for the transformation of traditional food supply chain considering Blockchain Technology. The model promises to give all stakeholders participating in the agricultural food supply chain equal opportunities even if they are not familiar to each other but without the help of trustworthy third party service provider. We validate proposed blockchain based smart model with our own scheme without using blockchain.**

***Index Terms*—Foodborne, Smart Mode , Blockchain, Scheme**

I. Introduction

With the advent of technology and dependence on services provided by Information Communication and Technology, the need for secure and trustworthy record storage has been immensely felt. Blockchain is one such promising platform that records transactions of any kind in a chronological order through distributed and shared ledgers in the vast network as depicted in Figure 1. These transactions in a blockchain network may include money transfer, provision of services, healthcare records, hotel reservations, flight itineraries, confidential contracts to name a few.

Furthermore, blockchain also enables one to record and track asset ownership's when leased to third parties. Similarly many other significant and valuable resources can be recorder, leased, exchanged as well as tracked on a blockchain platform. This also enables there respective duplicate transaction records which are shared at the same time with in the blockchain network with all the stakeholders. Additional records are further secured by encryption keys or mathematically constructed keys for ensuring security [2].

On the blockchain platform transactions are verified and processed within the blockchain network so people do not need intermediaries to establish trust. In fact, economists define blockchain as a machine of trust so trust between people is not necessary. In other words, on the blockchain platform there is no need from the process for third-party arbitrators like banks and governments to get involved to confirm or approve transactions. Removing mediators simplifies the process and expressively reduces transaction cost and time [3].

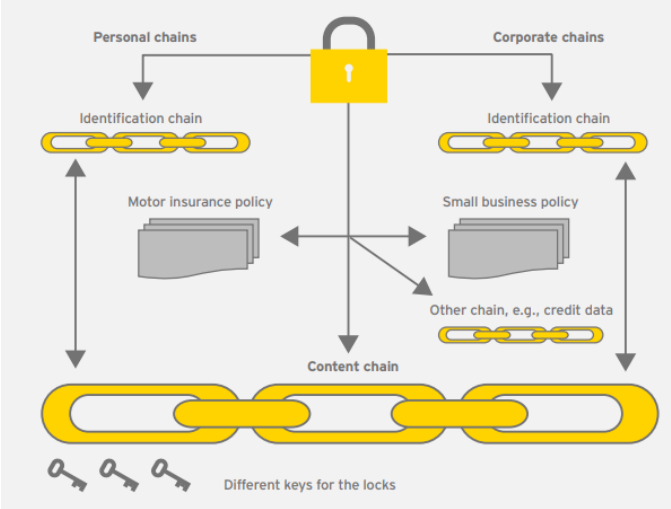


Fig. 1. Shared ledger blockchain Technology [1]

Blockchain technology's basic concept was explained in back in 1991 when scientists Stuart Haber and W presented a technically viable solution those timestamped Scott's digital documents to prevent them from being hacked or manipulated. The system used a password protected blockchain to store timestamp documents [4]. In 1992, Markle Tress was integrated into the design, bringing together multiple documents

in one block to make them more efficient. However, this technology was not used and the patent expired in 2004 four years before Bitcoin began [5]. Beyond Bitcoin blockchain technology has the potential of innovating many aspects of business and transforming many sectors including agricultural food supply chain [6] as shown in Figure 1.

Nearly half of Pakistan's workforce and 40% of the world's workforce are engaged in agriculture which is the world's largest sector of job provider and has potential to affect billions of lives. In addition, in the food supply chain as consumer demand for transparency increases that results producers and manufacturer find it difficult for providing accurate data to the table from the farm. This promises for improving the transparency and traceability of agricultural products. Unfair prices because of price constraints, overdue payments, high transaction fees and the presence of brokerages are another challenge in the agricultural supply chain [7].

Second, food transportation and logistics is complex and sometimes require a supply chain within the continent. This supply chain includes dozens of employees and hundreds of interactions that are more prone to human fault [6]. This technology has also the potential for making agri-food supply chain more transparent, secure and efficient. Promising end-to-end visibility of supply chain you can track the source of your products (origin) and track your products / products while moving into the supply chain. Implementing a blockchain solution can eliminate intermediaries or intermediaries, resulting in higher prices and lower transaction fees, eliminating cumulative issues [8].

Blockchain smart also enables contracts which provide the possibility to develop agricultural and food supply system and can change this system into a combined smart system that ensures the provision of safe food to consumer. In this work our main emphasis is leveraging blockchain smart contracts that are autonomously executed. A vast amount of collectively distributed blockchain mining nodes implement the blockchain functions and have a shared code for these smart contracts. These nodes mutually agree in order to address the final results. Any node which is capable of storing and authenticating the blockchain code can become part of the blockchain node.

Rest of the paper is organized in such a way that Section II gives insight on the recent state of the art work done in the domain of Blockchain and specially in agriculture and food. Section III provides the motivation for this work and our research problem. Section IV provides the proposed block chain model for Food Supply chain which is verified in Section V. Finally we conclude our paper in Section VI where we give insights on the proposed framework as well as provide guidelines for the future work.

II. Literature Review

The agricultural food supply chain mentions the process of food processing, production, distribution, disposal and consumption. Many studies have been carried out using various emerging technologies to ensure food security and maximize economic benefits in certain food supply chain processes; such as to clarify upstream and downstream activities of food supply chain management activities. A schematic supply chain diagram is presented in Figure 2 [9].

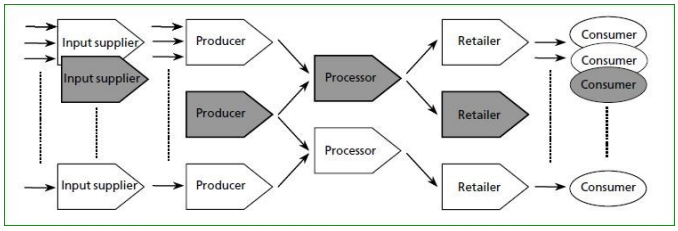


Fig. 2. Schematic Diagram of a Supply Chain

The old-style model is a composite chain of food supply flows which is mainly followed by traditional chains as shown in Figure 3 which outlines the traditional model of supply chain. Players participating in this model are auctioneers, commission agents, traditional retailers, wholesalers of all formal stores, and shops along the road, suppliers of pavement and trolleys and customers. Agents, auctioneers and wholesalers are sellers in the food supply chain. In the supply chain model, farmers sold their products to their consumers via a variety of intermediary partners who consume a full share of market prices second there is no option to track and track food in the system in order to deliver safe food to the end user [10] as shown in Figure 3.

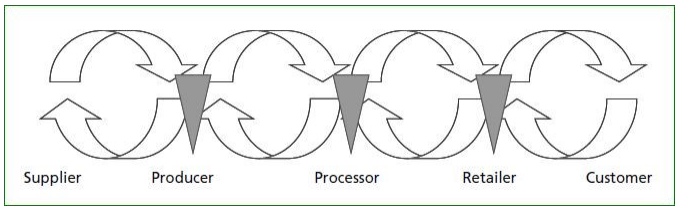


Fig. 3. Traditional View of a Supply chain process

Blockchain technology is revolutionary next step for the transformation of traditional food supply. In supply chains the blockchain technology can be utilized with each exchange being made with its conveyed records from the end goal to anchor trust. All records of all exchanges are time steps and combined with the previous case. This blockchain provided points of interest to inventory networks such as awareness, simplification, and requests. Approved people simply have access to the records on the blockchain. This means you can share and pin records as shown in Figure 4. With the help of sensors, perception and product follow-up can be assured and this data can be integrated with blockchain innovation managers to provide less risky information [11]

The authors showed a supply chain tracking system with a focus on transparency based on blockchain for food safety and HACCP (Hazard Analysis and Critical Control Points). There they described the crop process plants from harvesting to retailing in different phases of a performance analysis without going into the details. Generally, as far as we know some of the main features provided by some blockchain

Fig. 4. Rise of Blockchain Technology in supply chain

implementations remain unused or not fully utilized after autonomous transaction capacity (often called smart contracts [12].

Researchers proposed a blockchain model where data that streamed between gatherings will be maintained by both open and private records for supply chains. Personal records were used for shipments associated with specific records where each shipment only accesses meetings associated with the shipment. This is because data related to delicate products such as medicines kept our personal information better. This personal record contained data about cases involving a specific delivery. The second type of record is the general society record and included a considerable number of cases presented in personal records which could approve the interface of the shipment and truck area via the data in the personal record. General society record incorporated hash estimations of personal events and the records of those occasions were kept up on people in general record by presenting the hash esteems. The general population record was accessible to everyone dissimilar to the personal records [13].

Researchers developed Credit evaluation system based on blockchain for multiple stakeholders in the food supply chain. System is successful in the food safety sector. Blockchain guarantees the reliability of the food supply chain financial records and credit evaluation of traders. The drawback within this system is that it has only credit dealing functionality [14].

III. Motivation

In terms of technology and IT systems, the literature in food supply chain management on usage of blockchain technology is very limited and all of the above studies are the first and most important issue that has been done in the field of supply chain networks and other important issues of stakeholders (farmers and consumers) are not addressed to make the entire process fair and trustworthy. Therefore, in our research a new smart food supply chain model is developed that covers the entire supply chain process and food production process using blockchain technology. It can efficiently imply the information sharing with farmers and consumers and the traceability management can be realized throughout the food supply chain and will solve the biggest centralized format problem that it is asymmetric, opaque and monopolistic.

IV. Blockchain based Smart Model for Food Supply Chain

Blockchain provides developers with the power of smart contracts which have possibility to develop agricultural and food supply system and can change this system into a combined smart system that ensures the provision of safe food to consumer. These smart contracts are executed in a very automated fashion thus ensuring a very integrated and smart experience for supply chain management.

The database that shared by all mining nodes the nodes also record data as well as results of business deals in a ledge. Smart contracts receive business deal data and other communication in blockchain within the kind of function calls and activate actions to permit sharing individuals to regulate, trace and receive appropriate warnings in case of violation. Smart contract finally assists to revive best conditions and reply to violations within food supply chain.

Figure 5 shows a general overview of this research work smart food supply chain model architecture. The major participating entities, as shown in the figure, comprise the seed seller, the farmer, crop buyer, processor, crop storage, distributor, retailer, end customer, and the blockchain smart contract. In this system each stakeholder has an account in blockchain smart contract with exclusive address for their unique identity. Each stakeholder has a role, partnership, and smart contract interactions. There are eight stakeholders involved and their role is mentioned as follows:

Seed Seller

Seed seller or Vendors produce a wide variety of seeds and sell them to the farmers. The seed company services are strongly assisting food security that enables farmers to access quality seed, certified fertilizers and other nutrients to plant materials that boost farm production. The seed seller prepares the seeds and stores information on seed germination, chemical composition, viability, efficiency and dormancy to ensure safe monitoring of the products using smart contracts and to include all stakeholders throughout the process. The seed traded by the seed vendor is branded with generic yet unique identifiers such as serialized Global Trade Identification Numbers (GTIAN) or the preface of the product's code. These identifiers allow both these product as well as the transaction related processes between the stakeholders in the agricultural supply chain to be electronically identified and followed up.

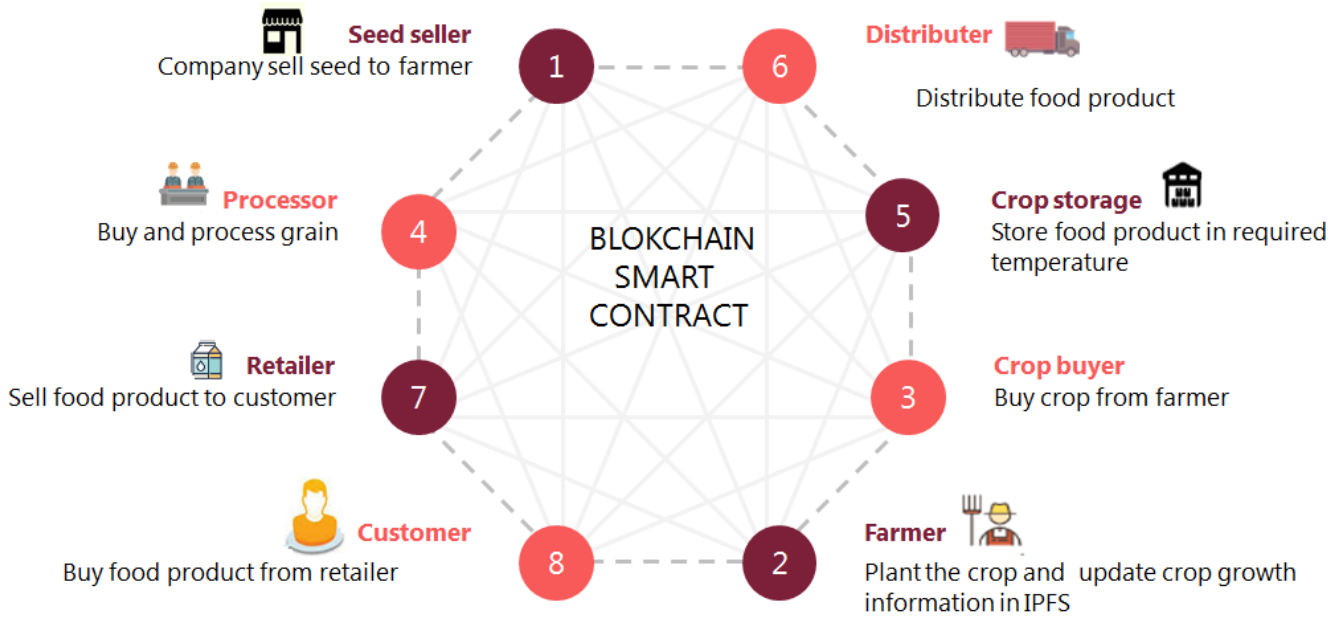


Fig. 5. Blockchain based smart food supply chain

Farmer

A person who possesses or manages a farm is called Farmer who purchases seeds from the vender (Seed Seller) with good quality and loT-based traceability. Seed sellers are responsible to enter all important information regarding seeds in to the smart contract where farmer can view and purchase seeds to plant their crops. The responsibility of the farmer is to monitor and record plant progression information and storing them as photographs or MPEG files on the distributed file system known as IPFS where various nodes store the data with high reliability. The farmer purchases the seeds from the seed sellers and plant the crop.The farmers are responsible to put all the information about crop growth in the system on proper time. The photos of crop growth are time-stamped and the file's IPFS hash is stored in the smart contract.After analysis of important factors such as temperature, humidity and timing the farmer records all the changes in the system from planting to harvesting. Through blockchain farmer also make contact with buyer to sell their produce without getting help for mediator.

Processor

The processor purchases the grains from the elevator, upgrades the grains, performs moisture analysis, removes scum, and converts the raw grain in the finished product and records all information in blockchain smart contract for visibility to other stakeholders involved in supply chain.

Crop storage

In future agriculture product differentiation mainly in quality will be crucial to getting a plus on conventional product price in this scenario crop/grain storage will play an important role as well as the grain storage facility offers operational and monetary benefits it depends not only on correct operating system but also on effective technological and marketing administration. Crop or grain storage information is also recorded in blockchain smart contract.

Distributors

Distributors are firms that take stock in bulk from manufacturers and sell consumers a package of related product lines. The wholesalers are also known as distributors. They typically sell to other businesses and sell products in larger quantities which would generally be purchased by an individual consumer .The entity that buys food products, warehouses them and resell them to retailer or direct to end user. Responsibility of the distributor is to record all data about food product in blockchain smart contract.

Retailer

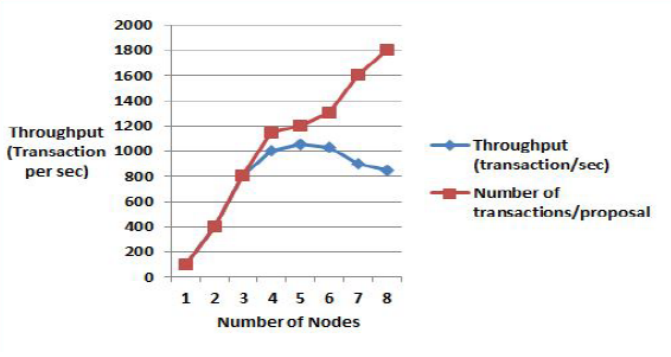
Retailer usually buys finished goods in batches of traceable identifiers from the distributors and sells them in small quantities to customers.

Customer

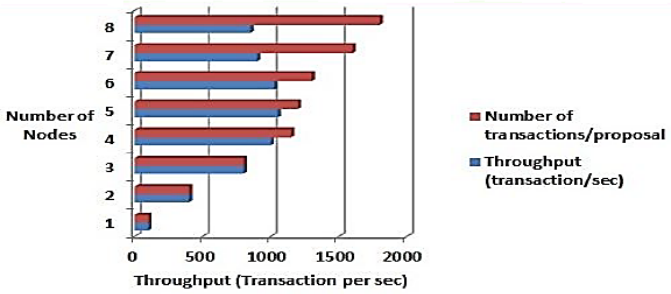
A person who purchases food product from retailer and then consume it. The customer in this setup is able to track or trace all information about the product from produce to sale point to ensure that the food product is of good quality or not.

All image and transactions are digitally signed and given to all stakeholders in blockchain and IoT. Stakeholder who uploads photos the farmer who uploads MPE files are the undoubted owner of such act and are accountable for wrong

or untrue acts. Blockchain can be automatically configured this information into smart contracts to penalize the farmer or other stakeholder if dishonestly observed. The installation of features and contact cameras in the field is another option to collect pictures automatically and send to the blockchain for registration, storage, and auditing and trust purpose.



(a)



(b)

Fig. 6. (a): Throughput Versus node deployed and (b): Throughput Versus node deployed

The benefit of using traceable technology in Pakistan supply chain via our developed smart model is the accessibility of real and non-moldable data to all stakeholders without getting help from trusted third party or central authority in supply system.

V. Model Validation

Proposed scheme for blockchain based Smart model is shown in Figures 6a and 6b. As we find no such scheme in literature, we have therefore validated our scheme with our own scheme as given in both figures with the blue line. The blue plot shows the throughput with respect to the implementation of the traditional food supply chain while red plots suggest an increase with the utility of blockchain in our initial scheme. The findings show a huge increase in traditional systems.

VI. Conclusion and Future Research Directions

Blockchain delivers real-time information on the safety status of food products to all supply chain participants, extremely reduces the risk of centralized information systems, and makes it safer, more distributed, more open and more collaborative. Our Smart model will significantly improve the food supply chain's productivity and reliability which will naturally boost food safety and restore consumer confidence in the food industry. We compare the performance of our smart model with traditional food supply chain model and MATLAB simulation results shows better performance than that of traditional model.

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