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Grainchain –Agricultural Supply Chain Traceability and Management technique for Farmers Sustainability Using Blockchain Hyper Ledger

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Abstract: Agricultural sector come across assortment of vulnerabilities in the domain of supply chain tractability such as adulteration of grains, unfair pricing and stocking of the grains which even leads to inflation. Current manual or semi-automated supply chain management solutions are built over the top of the centralized database management systems which may be subjected to vulnerability, lack of data integrity and single point of failure. Introducing Blockchain in the field of supply chain management will avoid tampering with data and single point of failure. Blockchain promotes trust in lack of trust environment. Grainchain is a rice tracking system. This system enables the tracking of the grains right from farmer to retailer. Grainchain promotes trust between the end consumer and the product they buy. Grainchain is a completely decentralized and permissioned Blockchain based application which enables the participant to perform transactions with each other. It also facilitates the end consumer to track the commodity right from the farm to their plates. Grainchain is built using Hyperledger fabric. Hyperledger fabric is permissioned Blockchain software which is suitable for all supply chain applications

Keywords: *Supply chain, Agriculture, Block chain, Hyperledger, Transparency*

1. Introduction

Supply chain tractability is the process of identifying; tracking and tracing the products as it moves from raw material to finished products which are sent to the markets as selling goods. Agriculture is the main sectorin India where the products which are grown in fields need to be sold in the markets. The goods need to be traced from storage to markets to avoid illegal stocking of the product. Illegal stocking of rice may lead to unfair pricing which affects every end consumer. Hence the tracked data must be stored in a database in order to track it. If supply chain traceability is implemented, it reduces the chance of adulteration of the food products such as rice. Here we have taken the rice as the food product and we can store the data about its production to sale. Since the data about the intermediary has been stored in the proper way, the end consumer can verify the validity and the higher officials can check stocking of the product.

The supply chain traceability for rice is already implemented using centralized database which has several security related issues. But storing the data in centralized database and retrieving it involves less effort and the data can be retrieved as faster than storing it in Blockchain. The implementation of supply chain management in public Blockchain using Ethereum added more security by storing every data in the nodes of the Blockchain [1]. But Ethereum is a public Blockchain and the data in the nodes is visible to all the participants of the blockchain. This is unfair, since showing personal data to all the participants is not legal. Hence, we need a permissioned Blockchain [2]. Hyperledger fabric is the modular Blockchain framework which can be used to develop permissioned Blockchain applications. Using Hyperledger fabric alone will not be user-friendly for all the participants such as farmers. Hyperledger [3] composer is the open development toolset to design user-friendly web applications.

P. carol[4] used two Blockchain implementations viz. Hyperledger sawtooth and Ethirium. Blockchain is updated with the data from an IOT device instead of traditional centralized cloud database. Hence the manpower workload of updating a database server is reduced and the database was made tamperproof one. The [5,6,7] same procedure can also be done with Hazard Analysis and Critical Control Points (HACCP) Blockchain to improve security and reliability by developing an application to include smart contract of ethirium.

Food products [8] traceability application along with Ethereum blockchain and IoT devices can be integrated to GS1 message standards to exchange messages between the nodes. The tractability chain [9] with EPC Information provided an off-chain and on-chain architecture to avoid

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data explosion. This enterprise smart contract technology improvised the query response as 1000 times for 1 GB data in 2ms. The smart contract technology [10] helps the agriculture sector to confront to standards in the stages of crop development and marketing.

The auqachain [11,12] distributed ledger provided a clear picture of using Blockchain ledger in water management system which can be coupled with farm management for transparency. Security [13,14,15] of data transmission between decentralized nodes can be improved with message security between the node's validator and customized digital circuit. Product [16,17] tractability information can be optimized with double layer framework instead of single layer.

The end-to-end model [18] was developed with ethirium system tracking to convert decentralized system with block chain using interplanetary file storage system to store details in smart contracts but the system does not consider the data transmission persistence and auditability. To impose data transmission speed and security [18] the data was kept in separate database and uploaded in blocks whenever needed as encrypted value with SHA algorithm and QR code. The consumer needs a QR code to verify their process.

The state of Art and challenges [19,20,21] in agricultural supply chain paved way to new solution to build an enterprise level product using blockchain. The block chain is used as an absolute circulated ledger for stocking grains and provide a suitable technology for traceability in the supply chain. The proposed system was developed using Hyperledger fabric, a Blockchain which was permissioned instead of using public Blockchain networks to improve accountability, security and data Transfer speed. Consensus protocols in the Hyperledger ensures trust between the various participating parties. The Main objectives of the System are

- To bring transparency to the process and to reduce the role of middlemen.
- Avoid stocking of the product and unfair pricing.
- Prevention of adulterating the grains.
- To improve accountability, traceability, security and transparency of the system.

2. METHOD

2.1. System Architecture

The system architecture diagram illustrated in Figure 1[22] the physical movement of product from the farmers to the end consumers. The data provided for commodity by the cultivators, suppliers at middle and retailers are added to the blockchain network. Hence the public who are end consumers as well as distributers, producers and retailers could track the flow of commodity along with the timestamp. only. Figures should be embedded and high-resolution files supplied separately. The stakeholders were given access rights to read and write to the Blockchain.

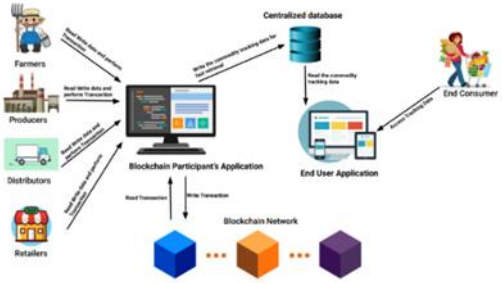

Fig. 1. Grainchain Architecture

2.2. Methodology

The Hyperledger Fabric was implemented in the project to improve the security in data transfer. The asset flow traceability and working methodology of Hyperledger Blockchain model is given below in Figure 2. The network contains four types of participants as Farmers, Producers, Distributers and retailers. These participants were the one owning the assets in the agriculture sector business. They were allowed to perform operations on assets which are food commodities. The participants across the network can be scaled up based on the requirement of food commodities to ensure availability of products as Hyperledger allows plugging the components based on requisite. The assets were the real entity ranging from crops to vegetables or any other ago products.

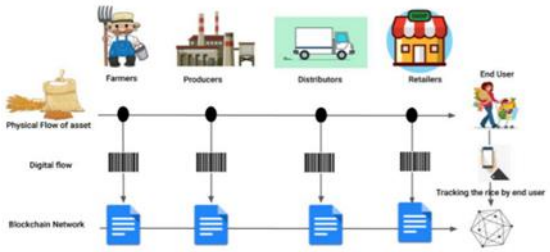

Fig. 2. Supply Chain traceability using Hyperledger Fabric

The Hyperledger provided the facility to run smart contracts for the permissioned membership. Permission for voting based consensus in the model. The transition block was appended to the Blockchain based on permission. The participant who needed the transaction will send the cryptographic hash and send to the peer for verification. The hash was sent only at transaction level where only the transacting parties were made peers to authenticate instead of all nodes participating in authentication. After verification the data was stored in the Blockchain.

The end consumers are also allowed to view the transaction even though as they are not part of network. This abstract view access given to end consumers made the model transparent and secure so that the commodity transfer is safe and secure starting from farmers to retailers without any illegal stocking or cash inflow.

3. Results and Discussions

The Hyperledger was implemented to provide transparency using Hypervisor. User-friendly front-end web page is created for ease of use for farmers. The farmers can add themselves easily through simple Unique ID verification. The project is tried with Tamil Nādu farmers to trace rice which is major native crop.

3.1. Ledger Formation

The distributed ledgers with blocks are formed to create the chain of supply for grains. Totally Five blocks were created as Commodity Block, Participant Block, Transaction block, Addressofparticipant concept block, and Enum data store. Since the Hyperledger is private blockchain, the nodes of each block created need to get permission before chaining each other which promotes enhanced security and transparency. The attributes and its type for the blocks created are given below in Table [1-2].

Table 1. Attributes and Types

Attribute	***Datatype***	***Constraint***	***Attribute***	***Datatype***	***Constraint***
	Commodity Block			***Participant Block***	
tradingSymbol	String	Primary key	traderId	tring	Primary key
Description	String		firstName	tring	
riceStage	StageOfRice	Connected to enum	lastName	tring	
riceType	TypesOfRice	Connected to enum	participantType	ypesOfPartici pant	Connected to enum
Quantity	Double		participantAddress	ddressOfParti cipant	Connected to concept
totalAmount	Double				
timeOfMakingCommodityOrMakingTransaction	DateTime				
Owner	Trader				
	Transaction Block			AddressOfParticipant Concept Block	
Commodity	Commodity	Foreign Key	Country	tring	
newOwner	Trader	Foreign Key	State	tring	
Issuer	Trader	Connected to enum	City	tring	
totalAmount	Double		Street	tring	
timeOfMakingExchange	DateTime		Pincode	tring	
commodityTimeOfMaking	DateTime				
CommodityOrMakingTransaction					

Table 2. Attributes and types

StageOfRice	***TypesOfRice***	***TypesOfParticipant***
BROWNRICE	BASMATIRICE	FARMERS
WHITERICE	SAMBAMASURIRICE	PRODUCERS
PACKEDRICE	BROWNRICE	DISTRIBUTORS
	WHITERICE	RETAILERS
	BLACKRICE	
	OTHERS	

3.2. Experimental Results

The commodity was added to the Blockchain using create commodity. Rice was considered as commodity and it is added as paddy (brown rice) initially into the network. Since paddy is a commodity that is produced only by farmers, this module can be accessed to create commodity into the network only by farmer participants. No other participant has access to this module. The farmers create commodity page was shown below in Figure 3.

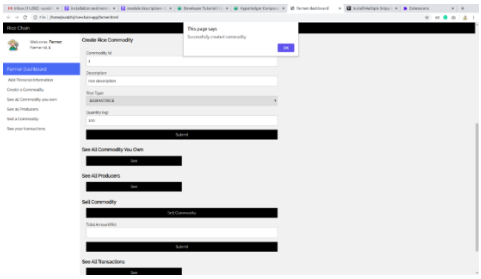

Fig. 3. Grainchain commodity Creation

The commodity will be tracked by admin using track commodity page. All the transactions made will be monitored by the administrator. The track commodity page is shown in Figure 4A and transactions page was shown in Figure 4 B. The tracking is performed by querying the network using the unique commodity id assigned to each commodity during its creation. This module is accessible by the administrator and the consumers. Consumers can access only abstracted information. The participants were given access to add the commodities or view the commodities. The farmer can sell the commodity to the retailer or distributer. The end user was allowed to see all distributors and retailers so that they can decide on how to buy and from whom to buy their commodities. It also improved the transparency of commodity and cash transaction. Farmers sell commodity page is shown in Fig. 4C.

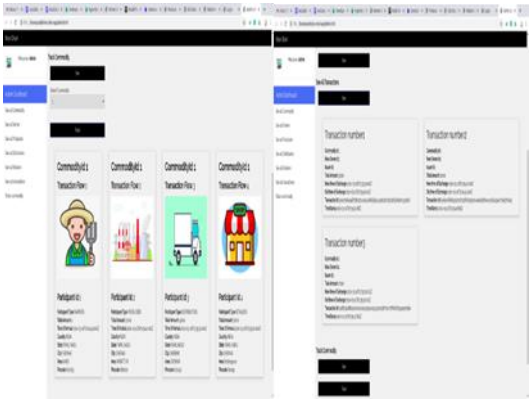

Fig. 4A. Track Commodity
4B. Transaction

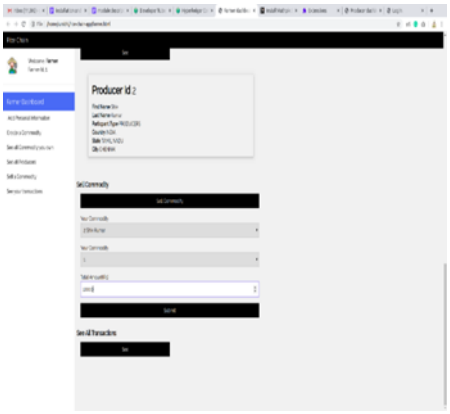

Fig. 4C. Seller Commodity

There are three stages of transfer. A farmer can sell the commodity only to a producer. A producer in turn can sell the commodity only to a distributor. A distributor can sell the commodity only to a retailer. The stage of product was changed whenever a sell commodity module is invoked.

3.3. Performance Measures Analysis

The work carried out using both public cryptographic algorithm Ethurium and also using Hyperledger. The Hyperledger seems to produce better results in transaction execution time, CPU Utilization. The process is also compared for accountability and data transfer and block allocation speed. The analysis is shown as graphs below in Figure 5.

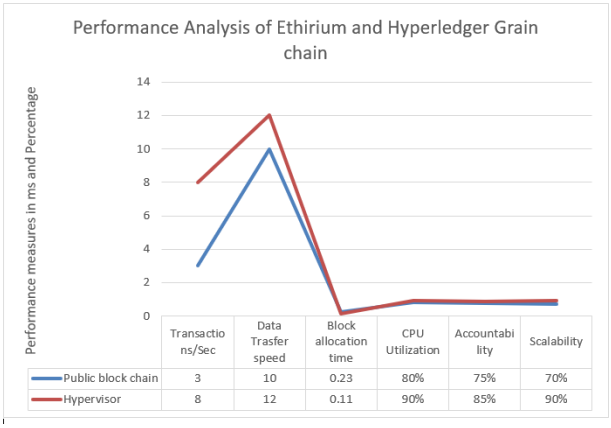

Fig. 5 Performance Analysis of grain chain with Ethirium and Hyperledger

The graph shows the transaction speed and accountability is improved for permissioned block chain rather than Public blockchain. The Analysis proved Hyperledger Fabric seems to be the best block chain technology for Grains supply chain management to improve transparency.

The proposed solution provides more accountability and security with transparency than existing systems discussed since the blocks are mined based on permission in Hyperledger and the log files are maintained to refer if needed. The farmers and consumers are authenticated to maintain authenticity and geniuses using unique id. The proposed solution does not involve any gas

fee for mining and it is affordable as it involves only one time setting up of private block chain network.

4. CONCLUSION

This Grainchain application can be extensively used by merchants and end consumer to ensure proper tracking from the farmer. Grainchain was the user- friendly web application which can be easily accessed by all the stakeholders involved. Performance and scalability were achieved because of plug in component feature of Hyperledger fabric model. Security and data transfer was enhanced with permission voting-based consensus algorithm which protects digital key and sensitive data. The proposed work provided the data based on need-to-know basis with rich queries on immutable distributed ledger. The model is implemented for grains but can be used as generic model to trace any Agricultural and Food products.

The work can be further automated using IOT devices. The data from IOT devices automatically validate and update the commodity details in the Blockchain which reduces the middleman in the application. The work can be further improved by introducing rating system to the producer, distributer and retailer so that the participants can check the rating before selling their commodity.

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