

# Blockchain and it's Integration with Supply Chain

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## ABSTRACT

Blockchain is the technology behind the Bitcoin, it was introduced in the year 2009 by an anonymous person named Satoshi Nakamoto. This technology showed a new way in which financial transaction are possible without any centralized entity involved along with the participating entity. Blockchain technology can be useful in managing supply chain effectively using distributed ledger technology. Distributed ledger spans the identical copy of it's ledger which is spanned across all the node in the blockchain network.

## General Terms

Blockchain

## Keywords

Blockchain, Cryptocurrency, Distributed Ledger

## 1. INTRODUCTION

With the improvement in the standard of living of the people and informed awareness among the people about the healthy diet in India people are more tend to food which trace their root to trusted source. Using blockchain we can have supply chain modified in a creative way. There are many factors which is limiting the supply chain in planning and exact tracking of items in the supply chain. Our blockchain system for the integration of supply chain will be essential for countering major problem faced by supply chain. According to a report by United Nations' Food and Agriculture, 194 million Indians going hungry daily despite the wastage of food worth about \$14 billion[1].

## 2. LITERATURE REVIEW

Agricultural supply chain has been studied at a large extent like, an agri-food supply chain traceability system was introduced by feng tian where they have showed how RFID along with blockchain technology can be used to solve some issues related to blockchain [2].

The data stored on the RFID contains the shelf life of the product and can be transmitted by sensor-RFID equipments from the warehouse containers, this system calculates the remaining life time of agri-food products in transmission. Ustundaga & Tanyasb (2009) [3].

Thomas Bocek in Blockchains Everywhere - A Use-case of Blockchains in the Pharma Supply-Chain made a list of application that are possible with the use of blockchain [4].

Even Government of Maharashtra is making use of the disruptive blockchain technology which can be used in the creation of tamper proof evidence of land record for the storing of owner detail in the blockchain network [5]. But there is lack of information that how the gap between the blockchain and supply chain can be filled, how exactly the blockchain feature can be used to enhance the supply chain traceability.

## 2.1 Observations

### Role of Food Corporation of India(FCI) in SCM

In Indian the FCI plays a key role in Procurement of food grain at Minimum Support Price(MSP) from Agricultural Producer. The Main aim is to transfer stock from surplus states like Punjab, Haryana to deficit state like North East, Jammu and Kashmir. There is no limit for procurement in terms of volume, any quantity can be procured by FCI(Food Corporation of India) provided the stock satisfies FAQ (Fair Average Quality).

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Initially in the absence of blockchain technology there was a need to share the information with all the members of the node. This technology will provide the decentralized copy of the information with all the node in the network. PDS(Public Distribution System) also forms a part of the network. As a result PDS will be able to find the amount of food grain it can distribute based on the amount of food grain available with the Storage. It need to query it's own blockchain copy. This will avoid multiple nodes querying the same database, and also removing single point failure if any, this makes handling of the problem related to database smoother. As Blockchain is distributed it can be easily queried on own copy of the chain and need not query database used by multiple stakeholders of the Supply Chain at the same time.

## 2.2 Interpretations

BLOCKCHAIN NETWORK: Bitcoin block size is limited to 1 MB now while a block is mined about every ten minutes. Subsequently, the Bitcoin network is restricted to a rate of 7 transactions per second, which is incapable of dealing with high frequency trading [6]. As the blockchain first application Bitcoin was completely pseudonymous our system need not be pseudonymous as the node are not public they are known and restricted in the network. The blocks the blockchain is linked by the hash of the previous block.

## 3. WORKING OF SYSTEM

### 3.1 Farmer to Procurement

The most crucial stage of the FCI as the food grain procured will be the part of entire supply chain till it is been consumed by the citizen of India. In a report submitted by High Level Committee (HCL) it was found that, Only 6 percent of total farmers in the country, who have gained from selling wheat and paddy directly to any procurement agency[7].

Here, the farmer who cultivates the crops maybe it wheat or rice will bring it to the nearest procurement station located. The farmer registers for appointment on FCI mobile app and gets a appointment for bringing food grains to the procurement store.

When the farmer arrives at the procurement centre all the data provided by the farmer is verified as in Aadhar Card and bank account detail. This detail will act as a record for the entry as a transaction in our blockchain record. The quality of the food grain will be verified and then the food grain bags will be formed along with the RFID tag attached to the bag and the data entered in blockchain. A single block contain many transaction which takes place in that time period, a size of size of single block is 1MB[6]. And the maximum data a single RFID tag can hold is 2KB. Here the transaction will be signed with the private key of farmer and transaction will be added to the transaction pool when data is forwarded by procurement centre. Digital signature is signed using private key and validated using public key of sender.

Digital signature helps to sign a transaction and avoid tampering with submitted transaction.

Here when the transaction will be added to the block by the nodes in the network in order for that block to be added in the blockchain. The block is only added to the blockchain when there is consensus among all the nodes in the network.

The transaction will the sender and receiver unique identification number as in the farmer will have his Aadhar card and the procurement centre will have its unique number assigned by the Food Corporation of India.

This node can add a block to the blockchain using consensus algorithm which is accepted by all the participated nodes in the network.

Bitcoin uses Proof of Work (PoW) algorithm where the miner node(who intends to add a block to the chain) has to solve a mathematical problem. This was required as the network is open so only the genuine miner will be able to add the block in the blockchain. But the problem lies in the amount of computation required which result in wastage of resource.

Tendermint which uses to add a block to the blockchain network by the use of the consensus protocol is a byzantine consensus algorithm which requires us to have confirmation from the node as the block needs to be added to the blockchain.

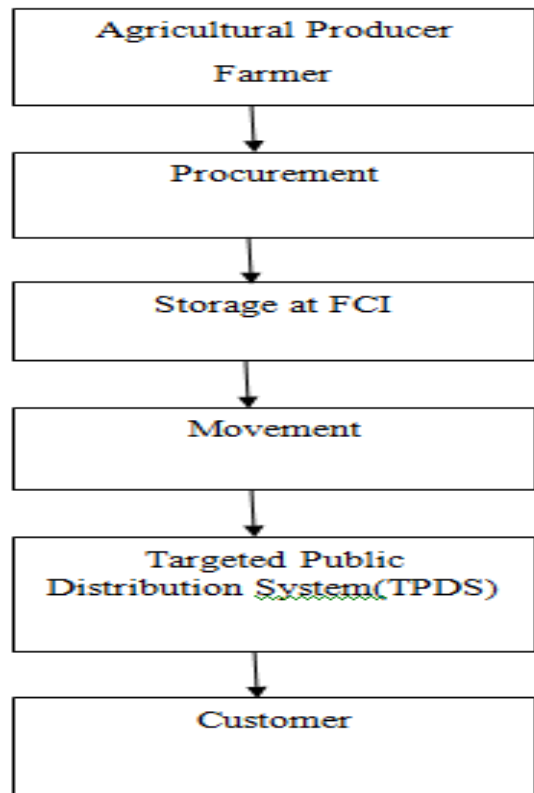


Fig 1: Actual Supply chain from farmer to customer

### 3.2 Procurement and Payment to farmers

After the process of buying the food from the farmer through procurement centre at the Minimum Support Price(MSP) the farmer need to be given his incentives for the food surplus that they have provided to the procurement store.

Here, the amount will be paid to the farmer not by human intervention but by the Smart Contract which will trigger when the food grain bag is added to the procurement centre. The farmer will be paid according to the data in the ledger the amount of bags they have given and the Minimum Support Price(MSP) for the grain so that they will be paid according to government mentioned price.

Smart Contract will be helpful in reducing the process of manually searching for the farmer record and then paying them the incentives for the same. Using this there will be accurate record and not tampering with the transaction with the record.

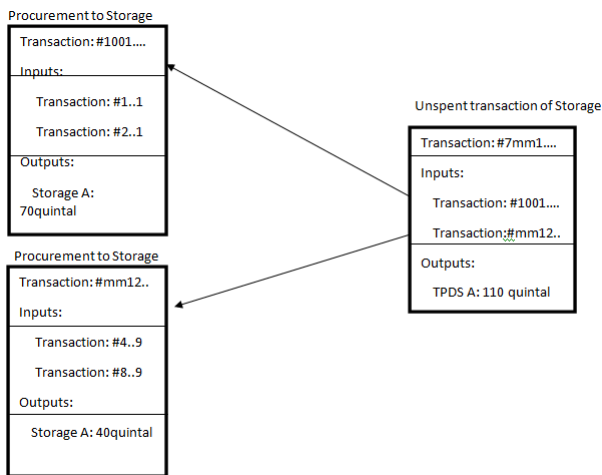
The procurement centre will then need to decide whether the stock needs to be transferred to the same state warehouse or to deficit state storage warehouse. As the state which cultivates the crops keeps the required amount of stock with itself to fulfil its need and transport the remaining to the deficit state.

The manager of the procurement centre will need to broadcast the transaction which he needs to carry out in order to send the grains to the storage centre, it will contain the recipients(storage centre) address. When the transaction is broadcasted to the network, the remaining node in the network will verify the transaction and with the public key of the manager of the procurement centre.

This check is made by the remaining nodes in the blockchain network and then the transaction will be added to the block which will then be added to the blockchain.

This food grain bags have RFID attached which will be

beneficial when identifying the record. The food grain can then be moved to Storage location where they will be stored in the Storage Warehouse. As the stock are stored as a digital certificate they are easy to be traced from where they came.



**Fig 2: Inputs and outputs in transaction's**

The inputs are the output of the previous transaction received to Procurement centre from farmer and this unspent output becomes the input of the to the next transaction. In this example, the transaction number (#1001..,#mm12) from procurement to storage becomes the input to the next transaction from Storage to TPDS. Here the input from Procurement Centre of 70 quintal and input from another procurement centre of 40 quintal is the total of complete unspent transaction of 110 quintal available with the Storage A in total. The total amount of food grain in calculated based on the number of unspent transaction.

### 3.3 Storage

After the procurement the stock will be stored in various locations as per need. As the stock moves the blockchain will be updated.

As the stock will be having the digital signature attached where we can easily find the existence of the stock in the blockchain. Total Storage with the entity will be the total of all the unspent transaction UTXO transaction. UTXO is the set of all the unspent transaction(food still with the storage) which is not yet given to PDS. If the food stored in the storage for any reason is not matching the quality of the food grain which can be tested by the QA(Quality Analyst) at any point in the lifecycle of the Supply Chain in order to maintain the Quality Standard of the food grain. The stored food grain can be traced back to the procurement store from where the item came.

### 3.4 Movement

Blockchain protocol follows that only the person having the private key of the asset can transfer the good. The movement of the food grain bags from storage to the TPDS where any alteration during the transport will be visible as the data can be traced in blockchain and cannot be tampered.

The movement is part of the network because the food grain need to be monitored when it is being transmitted from one location to another to keep a track to the food grain.

## 3.5 TPDS(Targeted Public Distribution System)

In this stage the food grain will reach to the Distribution System from where they will be one step away from general public for buying and consumption. This is crucial step where the food grain is going to be at our end user for consumption so quality and quantity also matter. At a particular Distribution System(DS) they will be having a particular amount of stock but blockchain doesn't store the final amount of stock and maintains the inputs and outputs of the food grain from the Distribution System. The total amount of stock will be the total amount of input with the DS.

This inputs are nothing but the Digital Signature signed by the previous owner. Normally there will be either a single input from a larger previous transaction or multiple inputs combining smaller amounts, and at most two outputs: one for the payment, and one returning the change, if any, back to the sender [8].

Digital Signature have provided integrity, non-repudiation, and authentication.

### 3.6 Customer

The customer will be given food grain based on the Aadhar card produced at the time of purchasing food grain. This helps to maintain the information of the food being only sold to general public.

In this case the finger print of the user will act as the private key of the sender. Which will be a transaction specifying in the blockchain that the food grain has been reached to general public. As the transaction is confirmed by the PDS shop owner the message will be sent to the Aadhar card registered mobile number about the quantity of the food grain they have received. This is to acknowledge the user that they can verify that the food grain is received according to the said quantity in the message. At the shop the customer needs to use the finger print in order to get the TPDS benefit as to give the benefit to general public.

As a pilot project this Aadhar verification should be tested in cities as there is will not be a internet connectivity problem. As main aim of FCI is to make food grains available at reasonable prices, particularly to vulnerable section of the society [9]. Multiple option of Aadhar verification should be open to general public such as fingerprint, OTP on registered mobile number.

## 4. BLOCKCHAIN IN USE

### 4.1 About Blockchain

Blockchain being immutable in nature can be very useful in creation on distributed ledger which will be accepted by all the nodes in the network. This leads to the principle of integrity and non repudiation of the data by the nodes in the network.

### 4.2 Key Characteristics of Blockchain Application

- Consensus protocol plays a very important role in adding a new block to the blockchain. The block is added only with the consensus of the nodes in the network. As we will be dealing with the private blockchain, It is ideal scenario to use Proof of Stake (PoS) consensus protocol as more right will be in the hand of entity having more stake in the overall lifecycle.
- Provenance is a way to track where the item in the cycle came from traces through the supply chain process.

### 4.3 Limitation with Supply Chain:

There are few limitation's with current supply chain where blockchain can play a key role.

- Backtracking- Backtracking is generally required when there is a need to backtrack a product to a chain of supply chain it basically root back to it's location from where it came.

So, if a TPDS becomes aware of a critical issue with fod grain for instance, participants of the blockchain network can view the entire history of that food grain from where it came(who possessed them before it came to the current node in the blockchain network) to find the root of the problem. And, whenever necessary, food grain from that specific farm or batch can be recalled rapidly.

- Forecasting- Supply Chain which also been used for demand forecasting falls weak when it comes to forecasting as the demand for the product increases the manufacturer as well as supplier faces difficulty to satisfy that requirement whereas when the customer demand is low the supplier stock may get unsold.

### 4.4 Smart Contract for triggering event

- Smart contract are self executing way in which code is used to trigger a event that is mentioned in the contract. This contract are formed after the mutual understanding between the participating parties in the contract.
- They are self executable and trigger when condition is satisfied.
- It can be implemented as a way to overcome paperwork.
- It can any intervention which is caused generally by the involvement of the middle man.
- The smart contract once deployed have their own unique address.

During the procurement process the farmer brings the food grain to the procurement centre and the procurement centre will be responsible to for the weighting of food grain and then processing the payment.

With the use of smart contract, the process will be reliable and automated for the payment carried out for the farmer. The farmer will be paid according to the amount of food grain they provided and the government decided respective MSP price.

Smart contract are self executable and can be used for minimizing the human intervention in the incentive to farmer.

This can be very useful as the farmer will get the accurate price for the food grain that they have given to the procurement centre and for the quality. They will be paid on time without any paper work required the money will be transferred to account.

### 4.5 Merkel Tree for validation

One of the most important datastructure to check the integrity and authenticity of the blockchain is the use of Merkel Tree. The Merkle tree root hash stores the hash value of all the transactions in the block [1]. Every block in the blockchain has a Merkle tree root hash stored in the header of block in the blockchain. This root hash has the hash of all the transaction in the block which it stores. The reason for the use of merkel tree and not using hash function is because a hash function will require (N) for validating the transaction in the blockchain.

In addition, Merkle Trees allow an  $O(\log n)$  proof-of-membership for any leaf node, which may be used for consistency or audit proofs in the set of data blocks[10].

Algorithm	Complexity
Hash Function	$O(N)$
Merkel Tree	$O(\log_2(N))$

## 5 STORAGE AND ACQUISITION OF DATA

### 5.1 RFID and Barcode

	RFID	Barcode
Cost	Expensive	Cheaper as compared to RFID
Storage	2000bytes,(i.e. 2KB)	80 character(1D barcode)
Accuracy Level	97 to 99%	55 to 80%
Technology	Radio Frequency	Scanner
Advantage	Can deal with large data	Lighter
Accessing Information	Scanner can access the RFID from as far as 300 ft	Scanner need to be near to the barcode not more than 15ft

Fig 1: Comparison of RFID and Barcode

The primary means of storage of information about a particular food grain bag is to store the information in form of RFID code or Barcode. RFID are suitable for use in supply chain as they can't be easily damaged. Barcode can be used as a pilot project as RFID tags are costlier.

As RFID tags have more advantage as compared to Barcode as the data can be perceived and added

## 6. CONCLUSION

The idea to implement Blockchain in Food Corporation(FCI) of India will not only change the way of how the FCI manages the supply chain but also help in managing major events of wastage and proper management of food grain. If there is a event where the FCI finds out that a particular batch of food grain is found to be adulterated which could hamper health of individual consuming it.

With the help of blockchain storage, blockchain network can view the entire history of food process from procurement till it reaches consumer. If needed the food grain stock from that specific farm or batch can be recalled rapidly. This will also lead to optimizing of resource at some stage. Also the targeted audience in the PDS will be benefitted by actually getting the share of food for which they have rights to be purchased and consumed.

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