A Theoretical Implementation: Agriculture-Food Supply Chain Management using Blockchain Technology

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Abstract - **The traceability of Agriculture food supply chain management is important to ensure the food safety. It also increases the customer satisfaction and peer-to-peer productivity. The centralized data storage makes it more difficult to assure quality, rate and origin of the products. So we are in need of a decentralized system where transparency is available which makes people from the producers to consumers satisfaction. Blockchain technology, which is a digital technology that allows us to acquire traceability and transparency in the supply chain. Making use of this technology actually improves the community between different stakeholders and farmers. The properties of blockchain essentially provides increased capacity, better security, immutability, minting, faster settlement and full traceability of stored transactions records. This paper presents a fully decentralized blockchain based traceability that enables to build blocks for agriculture that continuously integrate with IoT devices from provider to consumer. To implement, we introduced "Provider-Consumer Network" - a theoretical end to end food traceability application. The objective is to create distributed ledger that is accessible by all users in the network that in turn brings transparency.**

Keywords – blockchain, IoT, Ethereum, smart contract

I. INTRODUCTION

Agriculture is very essential for the living of the majority of population in TamilNadu. In terms of productivity of important and main crops, Tamil Nadu is in the lead. Achieving food security by increasing agricultural production forms the core of agricultural development strategy of the State. Agriculture development is predicated by improvement in farm production and productivity, better utilization of agriculture inputs, proper marketing infrastructure and support, and also efficient food management. Food safety seems to be an important area where there is an interest from both the producers and also the consumers. In Supply Chains, [7] by bringing transparency it helps us in improving the processes involved in production. Traceability is also very important that we can know the source of the item including details like the producer details, harvested and produced time etc., Agriculture system in Tamil Nadu requires a huge improvement to meet the increasing demands of it. Advanced technologies are being developed to meet the complex agricultural challenges faced by Tamil Nadu. Among those technologies, Blockchain is the most emerging technology. It is based on cryptographic hash. It is a decentralized and encrypted ledger system for storing transactions. This ensures that the transactions and the identity of the user can never be compromised. If such a fraudulent transactions occurs, the decentralized mining system will block it to enter into the encrypted chain. The most obvious application of Blockchain Technology is the supply chain logistics. In logistics,[1] blockchain gives a lot of options related to shipment data. All products and items could be tracked and this can help in preparing for any expected delays due to any conditions. We can utilize blockchain technology with the Internet of Things (IoT) to track the supply of perishable goods. We also have applications of Blockchain Technology (BCT) where assets are traded in exchange of money. In Agriculture Supply Chain Management, the transaction may include the data like quantity, raw materials, etc., Several crop insurance schemes like the National Agricultural Insurance Scheme, can be maintained using Blockchain Technology for tamper proof records and for periodic checking of settlement of claims during crop losses. The main advantage of Blockchain Technology is that it eliminates the need for third-party representatives as smart contracts can be used to settle transactions.

The remaining of this paper explained are as follows: Sec. II A general view behind the current process in adaption of blockchain as an qualifying technology for the traceability of Supply chain management in agriculture; Sec. III explains about how blockchain technology helps in food supply chain management; Sec. IV describes the importance of smart contract; Sec. V explains about Methodology and the value Tokens in Blockchain Sec. VI Overall process using Blockchain in Agri; Sec VII Integrating a new provider-consumer Software with IoT and Sec. VIII completes the paper.

II. RELATED WORK

The research and development activity mainly focuses on tamper-proof and immutable records in turn enables trust and reliability among untrusted peers within the financial technology. This concept made many sectors to identify Blockchain Technology as a platform for model shift. To achieve data reliability, Prov-Chain [14] travel around the use of Blockchain

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Technology in the area of Cloud Storage that verifies validation, storage and collection. It mainly concentrate in the terms of tamper-proof records and privacy. In same way, [16] smart-contracts helps to achieve secure data origin using Open Provenance Model (OPM) that access control-based privacy-preserving solution in the case of blockchain.

The application of RFID technologies in logistics [12], the devices and the sensors is literally revolutionizing each step of the process from autonomous identification system [11]. Especially in Agri-Food, the authors [13] explore the use of RFID and NFC based devices to obtain the goal in transparency and real-time information production directly on the field by adopting some IoT devices. Yet, the use of IoT and Blockchain Technologies is still in under progress. Chinese Food markets is one of the main focus in traceability system based on the blockchain and the RFID technology. A supply chain traceability system for food safety, based on HACCP (Hazard Analysis and Critical Control Points) focuses on transparency. The authors [15] described the different phases from harvesting to retailing without performance analysis. Smart Contracts [10] being referred to as autonomous transactions capability is one of the key-features offered in certain Blockchain implementation remains still in process.

III. BLOCKCHAIN TECHNOLOGY IN AGRI FOOD SUPPLY CHAIN

The important food crops that are cultivated in Tamil nadu are rice, cotton, tea, coffee, redgram, greengram, blackgram, jowar, bajra, maize, sugarcane, coconut, etc., Many technical implementations has been brought in the AFSC and farmers are also ready to welcome them. As the Supply Chain involves many problems like the sudden increase in demand for a product occur and the producer runs out of stock, Supply Chain management becomes necessary. Also customer satisfaction can also be achieved in a better way through Supply Chain Management. Supply Chain which involves all processes, flow of goods, information, etc., Fig.1 explains that the people involved in these activities such as producers, suppliers, distributors and retailers has to work together to supply a product to the consumer satisfying their needs. The traditional Supply Chain's traceability is based on centralized systems like cloud database uses IoT that provides no transparency and leads to security threats, tampering, data loss, etc.,

The main drawbacks of traditional Supply Chain are

1. Food safety cannot be assured at any stages
2. The detailed information about the origin of the product will not be available
3. Failed to provide transparency and traceability
4. Controllability – Life span of Control

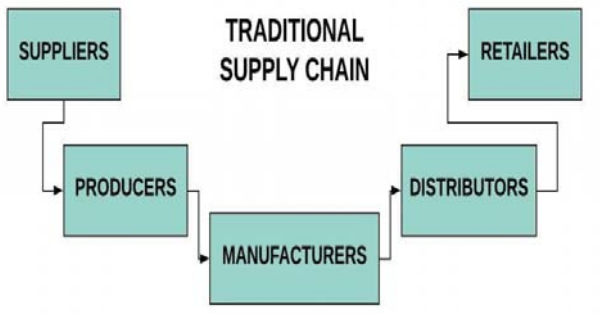

Fig. 1. Traditional Supply Chain

These can be overcome by using Blockchain technology which serves as a public ledger over a distributed network or all information maintenance including verification, validation etc.,[4] using which we can maintain tamper proof records, provide security and avoid third party intermediaries in transactions. It mainly reduces transaction cost and also improves quality of the product. The cryptographic method used here brings out trust among users which helps in demand for the product. The encryption techniques which are used in crypto currencies helps in verification of users and blocks. So here in a blockchain, each block contains information about transaction, and other details. Fig 2. The chain holds ledger from the beginning, when the genesis block was created. Here each block has a reference to previous block through a hash value. The peer-to-peer network [5] helps in validating new transactions and users. The Proof Of Stake (POS) algorithm produces challenges to be solved by users which is then validated and then added to the block if it is valid.

IV.USE OF SMART CONTRACTS

A traditional Contract is not efficient for blockchain technology. Also the traditional supply chains consists of large amount of paper documents which may result in less efficiency during tracking and theft.

Blockchain can help to overcome these drawback of transparency, efficiency, security and tracking by smart contracts which are automatically activated when predefined conditions are met. Smart contracts eliminate or drastically reduce the role of intermediaries. But smart contract is a digital contract that self –executes when predetermined conditions are met [3]. These self-executing code-based contracts allow agreed upon actions (such as Payments) to occur spontaneously, immediately and without middleman, upon the satisfaction of the terms of the contract. It is one of the main function which differentiates ethereum[2] from other blockchains. For example, a smart contract will release payment to a carrier when the customer confirms their parcel. Smart contract are special because one can program code that self-executes and no third party is required for it. This helps to reduce lot of time, efforts and money. And there's

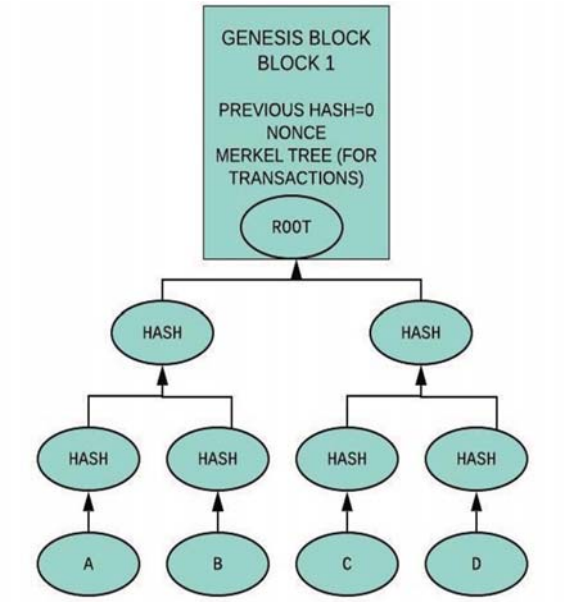

Fig. 2. First Block – Genesis Block

use of anyone to facilitate transactions and also no chance of user errors or frauds.

The smart contract is a promise among parties involved in a transaction that holds each party in authority for their role in the transaction to a traditional contract and also ensure that the contract is enforced. Smart contract improve the transparency, traceability and effectiveness of a supply chain allowing it to be more agile in strengthening the relationships among the parties. Each and every smart contract is assigned with a unique address of 20 bytes. The contract code can never be changed once the contract is deployed into the blockchain, user can only send a transaction to the contract's address. This transaction will then be executed by every consensus node in the network to reach a consensus on its output. There are two types of smart contract, deterministic and non-deterministic. A deterministic smart contract is when executing it doesn't require any information from an external party. A non –deterministic smart contract is a contract that depends on information (database) from an external party.

V. METHODOLOGY - TOKENS IN BLOCKCHAIN

The Ethereum Platform is an open source project that determines with two networks. One is a user account, which controls in a private key and address. Second is Smart Contract account that is controlled by code which is built inside. The code is compiled and ran using Ethereum Virtual Machines (EVM), which runs on individual nodes. The interaction between contracts are called transactions. The transactions updates the state of smart contracts allowing the state to be changed and viewed transparently from interacting with individual smart contracts. On top of Ethereum network the "Provider-Consumer" Network is built to globally access real-time transaction execution.

A. Tokens

The Ethereum ecosystem follows Ethereum Request for Comments (ERC) feedback system among users. ERC – 20 is a token framework which is used to build digital token on Ethereum network. Provider-Consumer exploits the ERC-721 proposal to track and create assets that will provide asset and non-fungible token standard. This standard help in integrating with Provider-Consumer with current Ethereum Platform. All the digital asset are created by its own with the help of ERC-721 standard.

B. Steps in transferring asset

- Using phone app
- IoT device that triggers a transaction

The tokens in Ethereum blockchain provide security that are approved in the ERC-20 contract. The Provider-Consumer software assign private keys to execute the whole transaction process. To operate on different phones ERC-721 contracts are used. It also provide level of abstraction for IoT device and users.

VI. AGRICULTURE BLOCKCHAIN OVERALL PROCESS

The Provider-Consumer Solution provides blockchain a most efficient structure of a database having a public ledger that includes digital information on the products, people, or events that can be accessed or inspected by many users. With the help of blockchain, there is a chance to

- Increase Transparency
- Reduce Error
- Prevents product delays
- Eliminate unethical and illegal activities
- Better management
- Increase the trust between consumer and supplier

The customer demands are increasing every day and to meet that we need an improved supply chain. Also for a better marketing environment, we can make use of Blockchain technology in supply chains. The supplier uploads the data about the food product like its harvested date, price. The Food product is then tagged with RFID chip [8]. The tags are placed on any items, ranging from individual parts to delivery labels. Inside the RFID tag, it consists of a microchip and antennae. Identifying information from the Special printers are used to print the tags which wirelessly load the identifying information to the tags. The information on the tags can be used for a various tasks .When RFID scanners scan the item, information is read from the tag which could include some necessary information that could be very effective in maintaining Supply chain such as:

- ID number
- Serial numbers for individual product
- Location logs
- Bin location of product
- Order status
- Its components

Fig. 3 explains the information can be updated and sent through any RFID receiver and the information is not limited to just holding ID and serial numbers .The information that RFID can provide will be matched with the system, to track shipment and stock locations automatically as the product moves through warehouses and Trucks. Implementation of RFID to these systems can ensure that both correct products and the correct qualities of product are collected at both points, thereby eliminating errors. Coupled with the IoT the product information can be tracked at all stages of shipment and storage, increasing accuracy, efficiency and accountability. The fully utilized RFID-enabled supply chain network can determine the product's location ensuring that theft and other illegal activities can be discovered immediately and enforced. After RFID tags are attached by the supplier, then producer gets information about the food product and adds QR code to packaging.

Then the product moves from producer to distributor, in which distributor automatically receives notification about the receipt of food products. Then Distributors chooses suiting 3PL (Third Party Logistics) [6] based on fully available data on customer, delivery date and other user information. Then 3PL (distribution, warehouse and fulfillment services) is informed about origin and destination of food products. It flexibly optimizes network flows. Now retailer runs a machine learning-based forecasting and also provide app for end customers.

The product information will remain the same. Then the product is ready for sale, it moves to market by retailers. The store has a full transparency on delivery time .They adopts orders, promos, etc. accordingly. All these transactions are takes place in Smart contract. Now at each process involved in production, each organization scans the RFID and update the details using mobile app to the blocks which are stored in cloud. So cloud also plays a major role in storing blocks. The verification, validation, transactions etc. ., all are done through the app or website. A mobile app and a website serves as a platform for communication.

The Blockchain Technology will starts to work when the genesis block is created, the details are stored in that and first transaction made is also added to it. Customers Scan the QR code via app and can view the products details from its origin, ageing, duration, and expiry and so on.

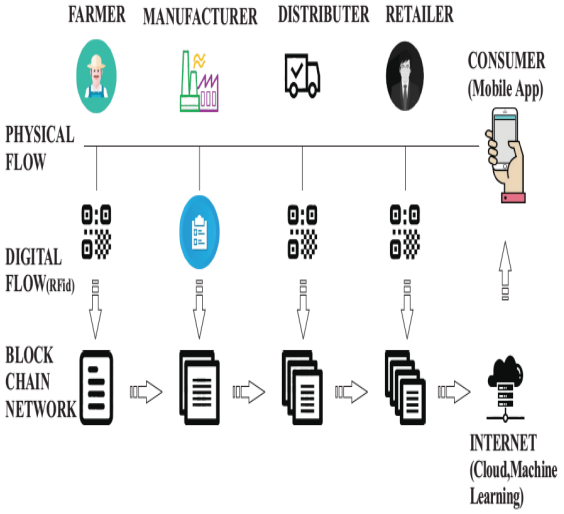

Fig. 3. Streamlined Form of Agriculture Food Supply chain in Blockchain

VII. Integration of Provider-Consumer Software with IoT devices

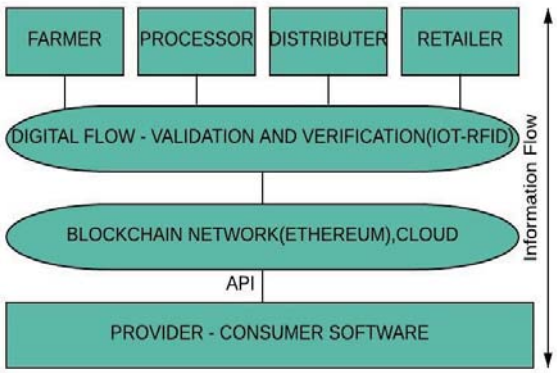

Fig. 4.Integration of provider-consumer software with IOT devices.

Fig 4 describes that the farmer is the first node in the network who can only create new assets. Every node in the network can add or remove data to the structure of the asset depending on the permissions. The overall process starts from the provider to the consumer who has read-only access to the data. The app which helps consumer to read the data obtained from the blockchain API known as Web3 API for the Ethereum network [9]. It shows the level of transparency in the asset that can be viewed by the customer.

Here ethereum act as a decentralized platform for maintaining data. The platform consists of three parts: Server, API (web3 API), Provider-consumer Software.

The Server connects Nodes that are run on ethereum to the software. The API of the ethereum virtual machine, which is present in the form of android library provides all the necessary functionalities of blockchain to the Software. The Provider-consumer Software allows the user to sign

transactions, interact with smart contract in any blockchain network.

Each and every item flowing through the supply chain must follow the food standards fixed by the Food Safety and Standards Authority of India (FSSAI). So there must be a well improved food testing center to check the harmful contents in the food. Table1. Explains that the food items may contain contaminants and it must undergo necessary testing processes. Also the supply chains can be integrated with Internet of Things using the Radio Frequency Identification system. These can be read by using RFID readers.

S.No	Food Items	Contaminants
1	Vegetables	Glyphosate
2	Fruits	Chlorpyrifos
3	Milk and its Products	DDT
4	Fish	Phosphates

Table1.Possible contaminants in frequently used food products.

A mobile app and a website serves as a platform for communication. Now at each process involved in production, the organization present in the network scans the RFID and update the details using mobile app to the blocks which are stored in cloud. So cloud also plays a major role in storing blocks. The verification, validation, transactions etc., all are done through the app or website. Theoretically, identifying the source of a defective batch of asset is handled in seconds and a push notification can be sent to customers about the hazards.

VIII. CONCLUSION

Blockchain technology is still at the development stage but it has been emerging as one of the better technologies in recent times. As agriculture is the most important field of the state, BCT can make a revolution in this field by improving the supply chains and also most importantly by providing traceability and security. It can dramatically increases the economic status of the country, reducing the corruption rate and increasing the satisfaction of producers and consumers. The Provider-Consumer Network is a blueprint for creating such a prototype to assemble the components. We described the usage of token, smart contracts in Ethereum Platform to integrate between nodes in the supply chain Management.

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