Proof of Quality in Organic Farm Produce using Distributed Ledger Technology.

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***Abstract*—With the increase in population, the goal to feed all is a high hill task. The excessive use of pesticides can improve the yield extensively for shorter gain but has long-term effects on the neuro system. As a result, governments are issuing laws to keep a check on the farm produce. Thus a decentralized, transparent system is need of an hour, which will rejuvenate the faith of the end buyer on farm produce. Our system uses proof of quality witha user-rank approach for creating credits of different users associated with farming. Thus our system suggests End-Buyers about suitable suppliers. Also, it punishes suppliers with non-ethical standards through our system.**

***Index Terms*—Proof of Quality,Distributed Ledger Technology, User-Rank, Supply Chain**

I. Introduction

Food security and traceability have received the most significant attention now and in the future. According to a study by the University of Oxford [1], by 2023, the world's population is expected to exceed 8 billion. This poses a challenge to the current agricultural system in high hill task, meeting the demand of 8 billion both in terms of quantity and quantity. Farmers use large amounts of fertilizers and pesticides on their farms to increase yields, which has proven harmful to the land and production consumers. Therefore, most consumers of the middle class and above have begun to develop health awareness about the consumption of their agricultural products. As a result, consumers now rely on credible agencies responsible for verifying their product's fertilizer and pesticide content, building trust among consumers. The health awareness of most societies for current agricultural consumption is generating new demands for organic agriculture. In organic farming practice, fertilizer, Pesticides, etc., are obtained from plants and animal products. The standard fertilizer that is still in use since the last century is cow dung fertilizer. Cow Dung manure is an excellent fertilizer that is highly rich in organic matter. Due to increased health awareness , the value of India's organic food market will reach US$849.5 million in 2020. With the support of the government's support plan, the organic-farm market expects to achieve a compound annual growth rate of 20.5% CAGR during [2] the forecast period 2021-2026. By 2026, the organic-farm market is hoping to reach 2.601 billion US dollars.

Therefore, active research is needed to track people's current quality and quantity demands (consumers) and farmers (producers) in capital and consumables. The sole purpose of this article is to introduce the supply chain between farmers and end-users. Our supply chain can track the origin of food in terms of quality and quantity. The use of blockchain in managing the supply chain has become a common trend. Blockchain technology provides security, traceability, and reliability to the supply chain, an indispensable part of the supply chain.

The paper is divided into the introduction section, working methodology section, and conclusion section. We provide a brief introduction to distributed ledger technology.

A. Distributed Ledger Technology

A ledger is a set of records that cannot be modified once it is written to a file/database (for example, a land-record database is an excellent example of a ledger description. Here, when a new entry is created for land, all previous entries remain intact, and the latest entry is inserted to the top, so over time, the stack of all transactions will remain on a specific land, with the new entry at the top of the stack. Distributed ledgers [3] are system-wide rather than using simple data storage applications in multiple locations. It manages users, policies and policies used to maintain records in the system. Typically distributed ledger consists of four parts: nodes, consensus algorithms, cryptography and shared ledger.

A node [3] is a system responsible for inserting and verifying transactions in the ledger between users. Management organizations usually maintain nodes. (For example: in the case of a land record system, the node is organized by

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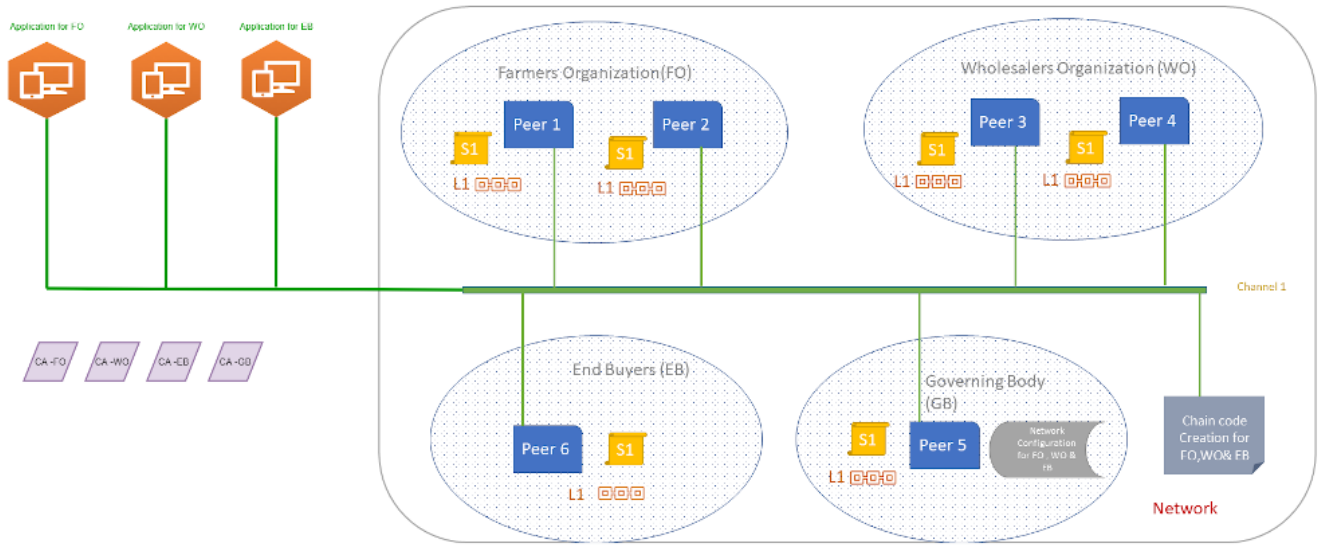

Fig. 1. Organic Farming Distributed Ledger Framework

a government organization responsible for maintaining land records). The concept of nodes varies from system to system, depending on the type of ledger used by the application. If all users in the network can participate in transaction verification, the ledger can be a public-ledger. In this case, the user behaves like a node because each user has a separate copy of the ledger, managed by them individually. For a private network, users with privileges can participate in the validation of transactions in the ledger. Therefore, duplicating the ledger on a large number of systems is an ideal solution for maintaining the ledger. Not all users participate in the verification process, so the system under a privileged user can act as a network node. The node definition is also affected by the network consensus definition.

A consensus algorithm is a decision-making sequence for approving transactions between the users. In general, a consensus consists of a validation process and updating the transactions over the ledgers. The consensus process may significantly depend on the type of data structure used in the trades, such as blockchain or directed graph with topological ordering.

Cryptography enables [4] the users to identify themselves and other users in the network securely. Digital certificates with SHA256 are mostly applied in the process of authentication. These certificates are also used in the process of validation of transactions between the users. Maintaining the same state of ledgers among all replicas is an uphill task. Thus replicas are mostly maintained using state databases that use key-value pair systems for recording transactions.

B. Supply Chain

Supply chain management is a process of transferring and transforming goods from the chain of users. It involves managing business in supply from senders to the receiver to maximize customer satisfaction and gain market capital. A supply chain consists of five parts.

1. Plan for developing a business module.
2. Supplier of raw ingredients.
3. Process of making final Product.
4. tracing of product from manufacturing outlets to the end buyers.
5. A feedback system for improving the business plan.

Our system's focus is to develop a good tracing strategy of farm products from farmers to the end buyers responsible for generating a broader income source for farmers in organic farming. Distributed Ledger can act as a business-friendly source of developing this system. [5] [6]The advantages of using Distributed Ledgers over other systems can be identified in terms of Anonymity and privacy, Auditability, Decentralized database, Immutability , Traceability, Transparency.

Tracing of Farm products can be done in various steps such as Traders, Farm-Organizations, Retailers. Pesticide residue levels of farm products can be tested at each step. High-performance liquid chromatography (HPLC), spectrometric analysis, thin layer chromatography are used to determine the level of arsenic in the products. [7]HPCL method is used to separate, identify, and quantify each component in a mixture. Total arsenic is extracted using Microwave-assisted extraction, Water-Based Extraction.

Spectrophotometry [8] is a method to measure how much a chemical substance absorbs light by measuring light intensity as a beam of light passes through the sample solution. Glyphosate herbicide residue can be determined using the spectrography method by studying effects on regents concentration and ph levels.

II. Methodology

A. Proposed Framework

We are currently developing a distributed ledger application on Hyperledger fabric shown in figure 1, responsible for

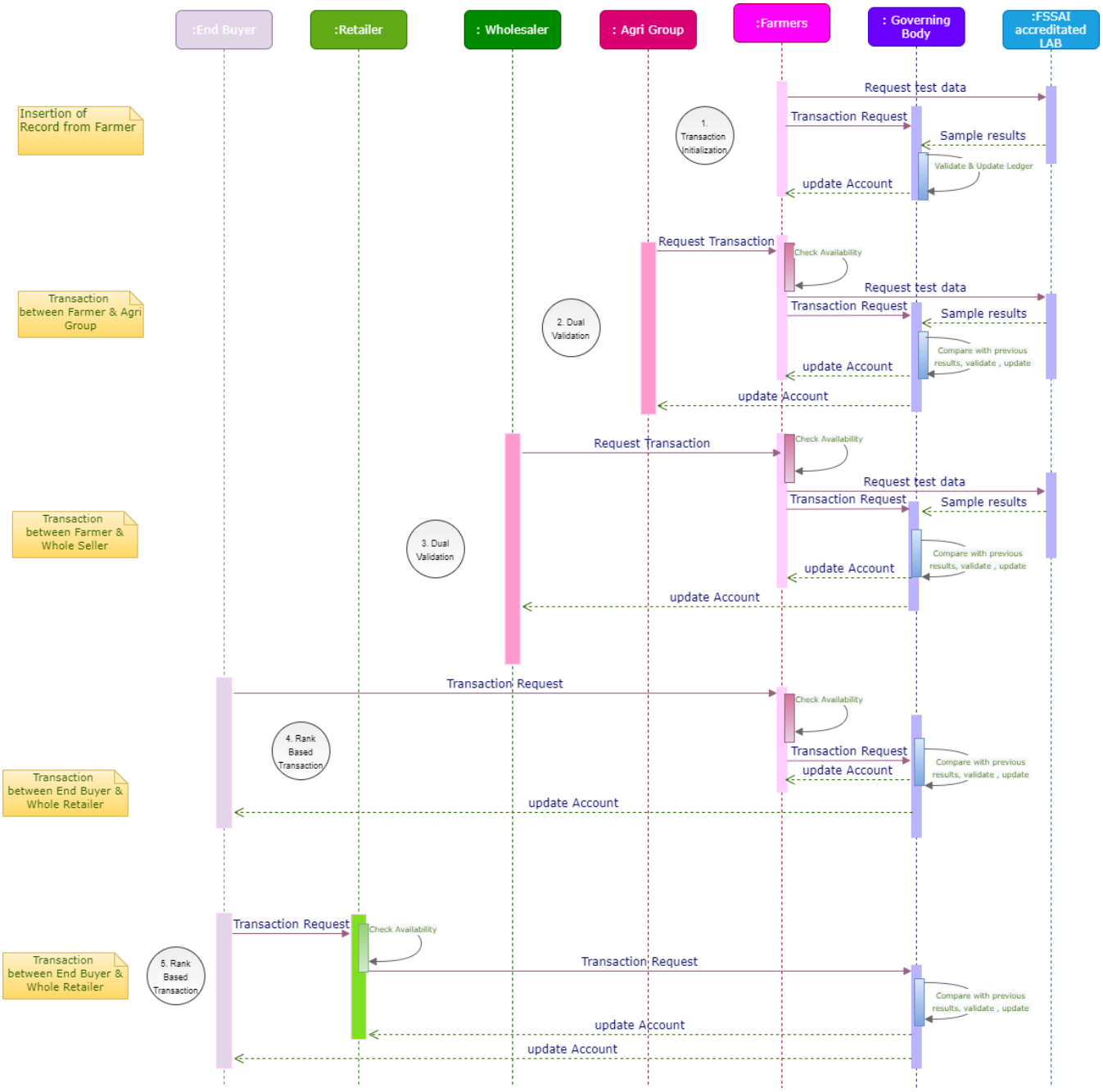

Fig. 2. User Based Transaction Flowchart

tracking and validating organic products. Our network consists of organizations, network-administrator, and transaction Chanel. An Organization consists of users who either perform transactions between the same or different organizations. Each organization manages a certificate authority that issues a certificate to the users of the organization. i.e., certificate authority for farmers organization (CA-FO) issues a digital certificate to a registered farmer under farmers organization.

Digital certificates issued by the organization identify users over the network. A farmer with a digital certificate can be seen by other farmers, traders, and end buyers while performing transactions. Each organization maintains a structure for storing copies of ledgers(L). The system for storing and maintaining a ledger is called peer. A peer can be a system privately used by the end-users of the organization or the computing structure created during the organization's creation. Farmers are using Peer1 and Peer 2 for storing and maintaining the records.

The network administrator (governing body) describes network policies for the transaction channel and sets administrative rights to the participating organization. Here governing body set rules for Farmers Organization and Traders Organiza-

tion. Channel is a mode of communication between different organizations. A quorum of organizations uses a channel to perform transactions over a common cause. The governing body forms a quorum of farmers, traders, and end buyers for the supply of grains like wheat and rice.

Smart contracts(S) are used for writing conditions of the insertion of records in the ledger. Our system allows transactions between farmers and traders as well as transactions between farmers and end buyers. Thus a single ledger is maintained by all three organizations. Updation of ledger needs smart contracts. To maintain the ledgers associated with the peer, every peer stores the logic of smart contracts in its system. Farmers, Traders, and End-users use the application provided by their respective organizations for performing transactions. The application's functionalities provided through the user interface ultimately trigger the smart contracts for performing ledger operations. Our framework uses one direction transactions to present the supply chain of farm produce. i.e., Farmers can sell farm produce to traders and end-buyers. Also, traders can sell goods to end-buyers, but the reverse is not possible. To achieve this, Policies are made during the creation of organizations that ultimately prohibits reverse transactions.

B. Transaction Flow

We have established three organizations: a farmers organization(FO), a wholesale organization(WO), and a governing body(GB) organization. Farmer's organization is composed of individual farmers or small agricultural groups. The farmers initiate the transaction by adding the record to the ledger of the agricultural products that the farmer is currently harvesting. For the product to be organic, according to the Food Safety Standards Agency of India (FSSAI) 2017 regulations[], pesticide residues in organic food must meet the stricter non-organic food limit of 5%. The average amount of metal containment, naturally occurring toxic substances, Insecticides and Pesticides as given in [Appendix A] are computed and verified in FSSAI-certified laboratories before inserting entries in the ledger, forming general validation about the farm product as shown in 1st part of transaction flow . Farmers also provide parameters such as seed type, harvest date, sowing date, seed count with 14% moisture level in 100gm, manure quality, quantity, area of crop to justify agricultural products price. These are important indicators for agricultural product's life cycle to prove the quality and quantity of agricultural products. The target user can only view the published record. In other words, users in a country/region can only view transactions that meet the maximum residue limit (MRL) set by the country/region. For example, the Indian government has set the MRL of metallic cadmium in wheat products to 0.2 ppm. Therefore, all records that meet the above restrictions are visible to Indian users.

As part of the supply chain, Farmers can sell farm produce to Farm Organizations, Wholesalers, Retailers, or End-buyers. Farm organizations, Wholesalers, retailers initiate transactions by placing an order request against the records published by farmers in the ledger. If the Available quantity matches against the requested quantity provided from the buyer's side, the seller initiates a transaction on the ledger. At this point, the buyer also sends the test samples to FSSAI accredited test laboratories to detect pesticide residues in the samples. The test results are returned to the governing body, where previous results are compared with current test results. Here the governing body re-validates the record previously available from the farmer's side, defining proof of quality for the record shown in 2nd and 3rd part of the transaction flow. Our system repeats the process for the succeeding transactions between Farm organization and Wholesaler, Wholesaler and Retailer, Retailer and End-Buyer for the same set of farm produce broadcasted from farmers side for sale. More transactions on the same set of farm produce indicate sound Proof of Quality.

III. Challenges and Solutions to Proof of Quality.

For any transactions between the End buyer and all other types of users, trust on validation of the last transaction is the only available option as the end buyer does not send the products for testing. Here other users (Farmers, Traders, Retailers, Farm Organizations) may send different products than the one tested. Our system uses a rank-based system [9] that generates rank for the users based on the transactions to overcome this situation. Group, Traders, Retailers receive rewards for each valid transaction. For an invalid transaction, the sender of the transaction receives punishment. Reward increases the rank of a user, while punishment decreases the rank of a user. When a transaction is processed between Farmers and other users such as traders, farm organizations, and retailers, the difference between residue levels and grain count per 100gm is computed as a part of dual verification. If the difference varies more than 10% with the previous result, the transaction is considered invalid. This is an ideal case when users apart from the end-buyer can send different products than the ledger's product. As a part of the punishment, users are marked, and their mean value is set to the highest mean value available for that type of user. For instance, if a farmer's transaction is computed as invalid during the dual validation process, then the farmer's mean value is set to the highest mean value available amongst all farmers. This process is also applicable for Framgroups, Traders.

A farmer's rank [10] is computed based on the mean residual difference available in [appendix A]. The system awards farmer with the lowest mean value with the first rank. If two farmers have the same mean value, then the system considers no transactions he has performed in overall transactions. The more no of the transaction indicates that the system has recommended the farmer for the transaction. Also, he has performed those transactions ethically. In case of an invalid transaction, the farmer's stake in his previous transactions is reduced by 50%. In the situation of having two farmers with equal no transactions, the farmer with more no transactions in 1 standard deviation is to be considered first. The above process is also applicable to Framgroups, Traders.

TABLE I
OPPORTUNITIES AND CHALLENGES

Stake holders	Opportunities	Challenges
Farmers	1.To sell the product at own decided price. 2. To introduce its own produce at a wider platform with new potential customers.	1.To keep the level of inorganic residuals as low as possible. 2. To incorporate ethical practices used in organic farming.
Traders	1.To get access to desirable products at a touch of fingers. 2. . Able to negotiate with farmers on their own terms.	1. Keeping produce in storage according to the norms of government.
Governing Body(FSSAI)	1.To collaborate with certified labs for providing testing services and generating revenue. 2. To generate a dataset of residual tests for further analysis.	1. To create a large no of testing facilities and collaborations for timely test results. 2. To reduce the cost of testing up to a level that is affordable for farmers.
Smart Startups	1. A potential market is developing, which uses applications based on sensors, Artificial Intelligence, and Blockchain technology for the crop life cycle.	1. The cost of using these technologies is greater than the production itself, thus creating the hesitation in farmers' minds.
Research Institutes	1. To get access to datasets available for finding consumer's pattern over farm produce. 2.To detect upcoming trends in farm produce.	1. To obtain a verified dataset from farmers, such as date of sowing, date of harvesting. 2.To obtain the actual amount and type of fertilizer applied from farmer's side.

For considering rank system amongst retailers parameters such as seed count and near vicinity are considered.

IV. Conclusion and Future Scope

Proof of quality provides a transparent and tamper distributed ledger system for the Organic farm industry. It encourages the users to have ethical practices and, at the same time, it disrupts the users with malpractices. The critical observations about opportunities and challenges for the vital role players such as Farmer, Traders, Governing bodies, Research Institutes are discussed in table I.

As a researcher, we will work on a separate distributed ledger system to trace the farmer's supplements using IoT, purchase order. Finally, we will integrate the current ledger system with the above system to form a complete Organic Farming solution.

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