

**FRAMEWORK FOR SEED QUALITY TRACING USING  
BLOCKCHAIN**

**BY**

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This Report Presented in Partial Fulfillment of the Requirements for the  
Degree of Master of Science in Computer Science and Engineering

Supervised By

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APPROVAL**

This Project/Thesis titled “**FRAMEWORK FOR SEED QUALITY TRACING USING BLOCKCHAIN**”, submitted by Sharmin Akter, ID No: 191-25-736 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of M.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on Tuesday 22 December, 2020.

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We hereby declare that this thesis work has been done by me under the supervision of **Dr. Sheak Rashed Haider Noori, Associate Professor & Associate Head, Department of**

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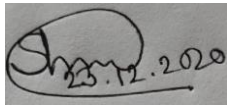


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## **ABSTRACT**

Seed quality plays a vital role in production of quality food and ingredients. World wide quality seed production is a known problem. With the advent of technology, networks, sensors and Internet of Things (IoT) with machine learning and artificial intelligence, there are efforts to trace the quality of seed production using technology. Blockchain, a fast growing distributed ledger based peer-to-peer network solution, has become a known



standard for developing trust based supply chain solutions to ensure transparency and efficiency using digital assets. In this research, based on blockchain architecture, a framework is proposed for quality tracing of seed production from the context of national needs. The proposed framework is developed based on the local business process of seed production. In the proposed framework, different blocks are conceptually defined for respective data at pre-production, production and post-production process of seed. The framework architecture for a typical system is also proposed and an interaction model is presented. A prototype of the proposed framework is developed for proof of concept using the Chainrider platform based on Hyperledger fabric. In the future, the proposed framework can be deployed in a production system in the cloud for the usage of the stakeholders based on APIs.

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# CHAPTER 1 INTRODUCTION

## 1.0 Introduction

With the rapid transformation in this pandemic time and Industry 4.0, Blockchain, Bitcoin and smart contracts have grown with the enormous popularity and industry adoption grown on a different scale. As we also realized that blockchain technology has become the biggest invention since the Internet, because it can disrupt many sectors, make processes faster and lower transaction costs with transparency. Along with this dramatic growth of Blockchain primarily due to digital currencies based on blockchain technology which is also valued.

Blockchain revolution started back in the year 2009 with an alternative currency called Bitcoin, came-up with a famous research proposed by Satoshi Nakamoto [1], that is issued and governed by a consensus system defined within the nodes connected and among users from the network. The electronic cash in the form of Bitcoin can be exchanged through the Internet in a decentralized, trustless system which deploys a public ledger known as Blockchain [2]. In the process of transactions, the component Blockchain is going to modify the way data is stored and connected in the connected nodes of a decentralized network. In this process of interactions, every record gets stored in a shared and transparent database where contracts can be embedded in digital code from the decentralized network formation [3]. Within the decentralized network, the existing business transforms and relies on other associated parties challenged by the Blockchain technology [4]. It is a known case that the Blockchain is able to deploy automatic mechanisms of trust without a central monitoring authority that helps to mitigate the risks and make operations more efficient [5]. As a result of this leverage of the trust model, it empowers finance, government, supply-chain and other related services [6].

In this technology era and with the rapid emergence of pandemic, a growing concern among the people of this planet embarked on living a healthy life at the face of pandemic. Healthy living is solely rooted to healthy food and its production. This naturally concerns parties related to food provenance and quality which are extremely high and this results in the tendency to spend more money on food products. Quality production of crops lies entirely with quality seeds and in most cases farmers suffer due to lack of quality seeds. Seed production to seed distribution with a quality tracing is only meant to ensure quality production of crops. In a national daily named “NewAge” opinion published in November 6, 2020 on “*In need of more quality seeds*” [7] shared that “Quality seeds are considered an important factor in increasing crop outturn. It helps greatly in higher production per unit area to attain food security. Among the cereal crops, rice is the staple food, accounting for more than 65 percent of the calorie intake. Crop yield can be increased by 15–20 percent through the use of quality seeds, keeping other factors constant.”

The article also mentioned that “In a study, it was found that 10-15 per cent yield can be increased by the use of quality seeds. The yield of almost all crops is low in Bangladesh compared with that in other countries. An inadequate supply of quality cereal seeds is one of the important limiting factors for lower yield. Still 46 per cent farmers can use quality seeds and the rest 54 percent of them depend on poor quality seed”. The article also expressed that “The national seed strategy should find ways to strengthen the informal seed system along with the formal system for sustainable seed supply. Although the net cropped area is declining, the total cropped area is increasing with the increase in area cultivated more than once. The cultivable land under cereal crops such as rice, wheat and maize is 120.95 lakh hectares. The cropping intensity has now increased to 215 per cent. The intensive rice cultivation is now dominating crop agriculture. In the boro season, 75 per cent area is covered by high-yielding varieties and 21 per cent by hybrid rice varieties. About 73 per cent aman area is used for high-yielding varieties and 27 per cent for local varieties. Wheat covers 3.70 lakh hectares. The area under maize production is increasing gradually.”



It is very clear that Bangladesh's national seed strategy needs a seed quality framework based on Blockchain to improve the seed quality tracing that leads to healthy living.

Traceability systems require decentralized networks. Most of the traceability systems available some way are centralized, maintain asymmetric communication and are somehow outdated in terms of data sharing and interoperability aspects. In most cases, due to traditional systems, the existing systems lack operational transparency. In order to create a transparent trust based seed quality tracing system with rapid technological development, it is observed to have a significant increase in emerging innovations based on information and communication technology (ICT). In the present context of research with seed quality tracing, distributed ledger technologies (DLT) such as blockchain is preferred as it offers a solution to many existing problems.

In this thesis work, a first attempt is made to understand and categorize the main Blockchain applications and respective characteristics in the seed tracing domain. Besides, a framework will be proposed based on Blockchain architecture to seed quality tracing.

## **1.1 Motivation**

The main motivation lies with the conceptualization, solution design, application of Blockchain. The key features of Blockchain technology is to define, communicate and enable the transfer of digital assets that ensure the original owner of the asset keeps intact. Blockchain can be thought of as a shared ledger or distributed ledger which is replicated and shared over all participating computers and servers, generally called nodes. This distributed ledger keeps record of all assets or digital assets stored in it and the history of them including which contributes what. As a result of this shared transparent information sharing, the assets can be traced with its roots from the back to their origin and can only be in possession of one entity from time to time. Once all participating nodes agree on one rule set which defines how the Blockchain is built up.

Besides, with the adoption of Industry 4.0 and a rapid increase in the application of the practical and effective usage of digital ledger technology (DLT) in the agriculture supply chain industry, it has grown with the spotlight in the academic research and also food industry communities. Industry 4.0 paradigm further renders DLT a promising area for further research in the future. As can be seen from national seed strategy needs published in “NewAge” on November 6, 2020, quality seed demand for a growing population of 182.3 million by the year 2025 is expected to embark further. Quality seed tracing using Blockchain is expected to leverage technology based solutions for quality seed production and management for the national needs.

## **1.2 Research Objectives**

From the discussion of the previous sections, the following research questions arise regarding the subject to be considered as part of the research objectives.

### **Q1. What is the architecture of standardized blockchain for seed quality tracing?**

In order to develop understanding about blockchain and its setup, related architectural views are created for seed quality tracing in order to answer following sub-questions: In which tier Blockchain for seed quality tracing works? What component architecture does the blockchain consist of for seed quality tracing? What are the main components of the blockchain for seed quality tracing and how do they interact with each other for serving quality?

### **Q2. What is the framework based on Blockchain for seed quality tracing?**

Blockchain solutions are used in many different ways and different platforms offer different strategies for adoption. Based on the proposed framework following subquestions: What are the proposed components of framework for seed quality tracing? How does the framework reflect on the seed quality?

### **1.3 Expected Outcome**

This research work intends to support the following expected outcomes:

*a. Conceptual Framework for Seed Tracing using Blockchain*

Based on the literature review and understanding of the Blockchain, its architecture, deployment aspects, platform, and collaboration issues in the distributed ledger, a conceptual framework for seed quality tracing will be developed to support the national needs of quality seed for farmers.

*b. Prototyping based on IBM Hyperledger or related platform*

Based on the proposed framework, a simulation will be performed in a platform to realize the implementation aspects of the framework.

### **1.4 Layout of the Thesis**

Based on the common understanding of the Blockchain based research work, the layout of the thesis is organized as follows:

Chapter 2 discusses the background of the work including introduction of the Blockchain, related architecture, seed quality tracing issues, Blockchain in tracing and related architectures, and other important reference discussions.

Chapter 3 discusses the applying knowledge from the perspectives of the background with application of use cases in Blockchain based seed quality tracing. It also discusses the framework components, use case development and implementation issues of Blockchain with introduction of platforms for Blockchain based solution development.

Chapter 4 discusses the proposed framework including the operational, governance and other aspects of the same to ensure the realization of the proposed framework along with the implementation challenges.

Chapter 5 discusses the outcomes and further directions towards implementation.

## **CHAPTER 2 BACKGROUND**

### **2.0 Introduction**

Food and food production badly need quality seed as it is one of the largest industries in the world. Besides it is also the most fragmented industry with production scattered all over the world. Keeping control of the supply chain of quality seed is therefore a costly and difficult task. In most cases the dependence on trust for quality seed in third party operations, ethics in production, transportation is delicate as well. necessary official validation and documentation, ITsupport systems, official certificates, nature of the food origin, mixing of food, the use of chemicals and fertilizers etc. are areas where bad practices can create problems on a large scale.

In the process of seed, the supply chain systems are complex and complicated, because of the sources and also the suppliers are spread on different levels and seed production processes are settled differently as conceived from the modern supply chain perspectives outlined in a good research [7]. It is undoubtedly the information which governs this complex and competitive process of supply chain environment for seed as the most important resource. As with the production of seed, every day a huge amount of data is produced and exchanged across different parties as it has been found in a research article of the same domain [8]. In seed production supply chain, based on the work of Mattila et al. which clearly states that the current supply chain arrangement as it is found to be affected primarily from information and informational inconsistencies between parties. This is a natural phenomena due to different party engagement with the supply chain stores its own partial copy of the product data, fulfilling its own informational needs.

In most cases, the agriculture industry lacks appropriate mechanisms that can ensure and track the production and distribution of good and quality seeds. Alongside it goes with the

farmers as they don't get correct and enough information about the origin of the seeds they would be sowing in the field during different seasons.

It has been found that during the harvest season alone, poor quality seeds hampered the productivity of at least 10%-15% of overall crop production.. Similar examples are cited for vegetable seeds, too as it is a common situation in all cases.

## **2.1 Research Strategy**

As the field of seed quality tracing is new and finding design principles along with the formation a design framework for implementing blockchain powered seed quality tracing is challenging. Due to the business domain affairs at grassroot level i.e. at the level of farmers, not much academic research exists for the field and so with the technology which is continuously evolving. Through literature investigations and through interactions with the domain and other stakeholders, a suitable approach to develop a framework based on Blockchain will be preferred. In the process of quality assurance for the seeds, supply-chain distribution management using Blockchain approach will also be referred. This approach is specifically applicable for information systems and systematic development where only little theory has been developed and people, organizations and technology are important.

The research strategy is shown in the following Figure 2.1.1.

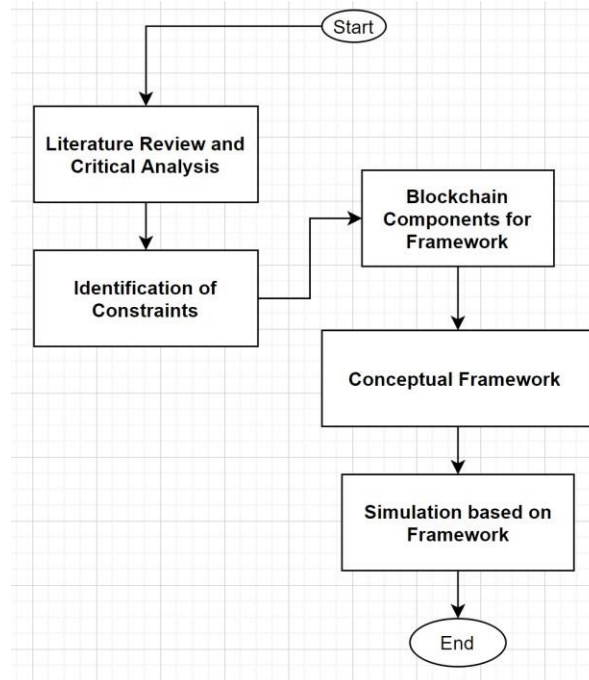


Figure 2.1.1: Research Strategy

The research approach is shown in Figure 2.1.1. It starts with literature review and critical analysis where problem identification and formulation takes place. In this step, research papers are reviewed and critical analysis is accomplished to address the research questions of section 1. After the literature review, necessary constraints are identified in terms of business process, technology and transformations. Based on identified constraints, necessary components and modules are identified for the development of a framework for seed quality tracing using Blockchain. Conceptual framework based on Blockchain for seed quality tracing is developed in the next step based on business process, constraints and interaction model of the stakeholders. The conceptual framework developed is simulated for the necessary validation and for the proof of the concept as an outcome of the research.

## 2.2 Blockchain Technology

In this section, different aspects of Blockchain technology are discussed to spotlight the background and knowledge issues related to application of Blockchain in seed quality tracing.

### **2.2.1 Blockchain**

Blockchain is viewed as the principle insurgency of Bitcoin. Over the years, Blockchain found its own measurement. Specifically, Beck and Müller-Bloch [5] portray two diverse Blockchain ages. The first observes a Blockchain that was simply intended to help digital currencies. The second era of Blockchain moved away from Bitcoins, permitting all sort of exchanges to be recorded in the public record specially in distributed ledger. Thus, Blockchain turned into a conventionally programmable stage that could be utilized for a wide assortment of executions [5].

Be that as it may, what is actually a Blockchain? A Blockchain is a public record where all the advanced functions executed among the organization's members can be recorded in consensus [6]. The record is formed by chains of squares and in each square it is put away by an elite of exchanges [5]. Previously being recorded in the public record, the functions are confirmed by agreement of a large number of the members [8]. This agreement is reached through an approval system that asks the goal of cutting edge cryptographic riddles. This activity is likewise called "mining". Just when the riddle is tackled, the new square can be added to the chain [5]. The Blockchain develops each time another exchange is executed, adding the new squares to the Blockchain in a straight and sequential request. Every hub that is associated with the Blockchain promptly downloads a duplicate of the entire Blockchain, from the beginning square to the last one [9]. Additionally, once the data is recorded in the framework, it can never be eradicated [9]. Along these lines, the Blockchain has total data about the exchanges history, saving the old and new adaptations of every data. Surely, the profoundly cryptographic highlights of the cycle make each altering provisional basically incomprehensible [5].

### **2.2.2 How does Blockchain work?**

Blockchain works in a peer-to-peer network within the distributed database and a schematic working of Blockchain is shown in the following Figure 2.2.1.

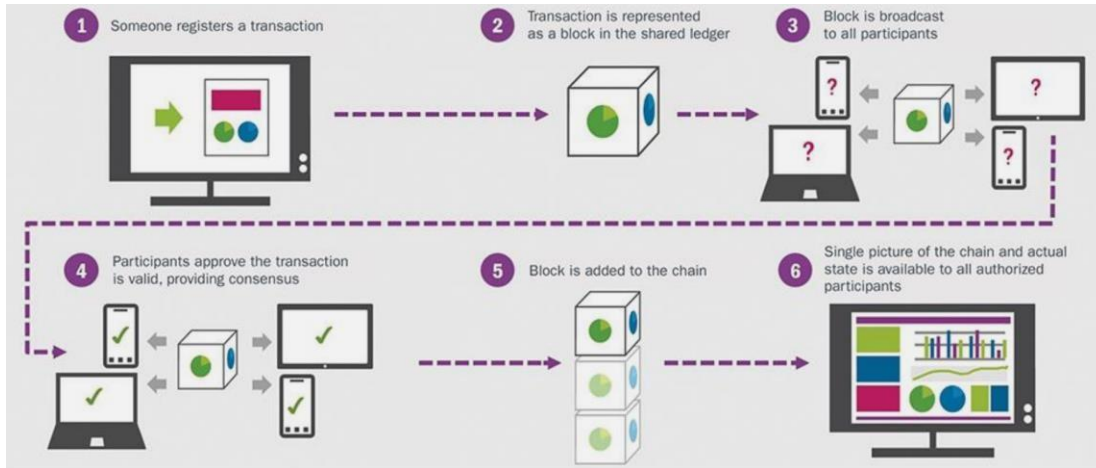


Figure 2.2.2: Working principle of Blockchain [10]

As seen from Figure 2.2.2, at the first step when someone requests or register for a transaction as shown in step-1, the transaction is represented as a block in a shared ledger shown in step-2. When the block is created, the block is broadcasted in the connected nodes to all participants as shown in step-3. The participants verified and approved the transaction through consensus mechanism shown in step-4. Once the transaction is validated, the transaction is unalterable and the block is added to the chain shown in step5 and the transaction gets completed in step-6.

Blockchain misuses the possibilities of the public key cryptography, to shield the security of the tasks. Subsequently, to execute any sort of trade, the client should be appointed both a public and a private key. The entire organization knows the public one, which particularly recognizes the client in the organization. The private key is utilized to carefully sign exchanges and should be left well enough alone by the client. Along these lines, just the client who can create a substantial mark with his private key can guarantee the responsibility for exchange [11].

The correspondence is performed straightforwardly between peers, rather than utilizing a focal hub as orchestrator. Every hub of the organization stores and forward data to every other hub [12].



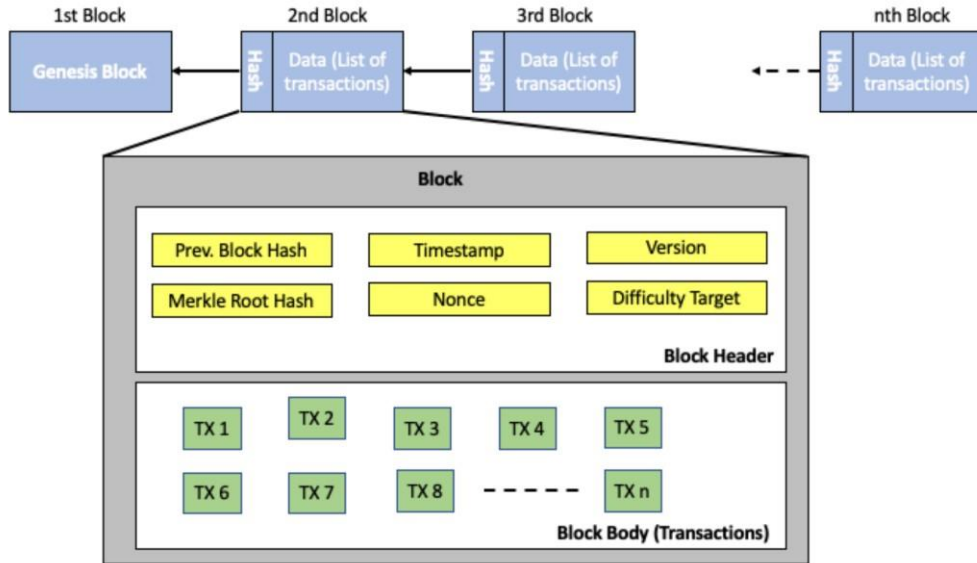


Figure 2.2.3: Example of a Blockchain containing  $n$  blocks [15]

As shown in Figure 2.2.3, in Blockchain, each consist of block header and block body. In block header, there are six specific piece of information; previous block hash: hash code as a reference to the blocks generated and linked to ensure each block is connected which is generated through transaction process of the users, Version: the current version of the block, Markle root hash: an encrypted hash of all transactions taking place in this block known as Merkle root hash, Timestamp: time of the creation of the block, Nonce: any random number that is assigned by a block creator that can be changed as and when required and the body containing data for the block.

Blockchain abuses the possibilities of the public key cryptography, to protect the security of the tasks. Consequently, to execute any kind of trade, the client should be appointed both a public and a private key. The entire organization knows the public one, which interestingly recognizes the client in the organization. The private key is utilized to carefully sign exchanges and should be left well enough alone by the client. Thus, just the client who can create a legitimate mark with his private key can guarantee the responsibility for exchange [10].

Another significant property of Blockchain lies in its advanced nature. This nature of the record ties the exchanges to a computational rationale that permits their programmability. Thus, it is conceivable to make decisions and calculations that trigger exchanges between hubs in a programmed way [11]. A case of this trademark are the brilliant agreements. Brilliant agreements are spoken to by PC code that is executed on the Blockchain. They work executing a bunch of predefined rules through a progression of on the off chance that does that. Along these lines, they ensure that the standards that were set up by the organization members are followed, without the requirement for a go-between [13]. In this sense, keen agreements can bring security assurance, mechanization and knowledge into a Blockchain-based framework [14]. Since brilliant agreements are actualized on the Blockchain, they acquire all the Blockchain's properties: they work in a completely computerized way, they are dispersed over the organization, and they are perpetual and carefully designed [5-7].

### **2.3 Seed Quality Tracing**

Seed quality lies with a complex production process and in Bangladesh, we have farming in different regions and divisional towns to help farmers with the seasonal crops. This section elaborates on the seed production aspects and the necessity of tracing for quality seeds.

#### **2.3.1 Seed and Agro Enterprise in Bangladesh**

Quality seeds are one of the vital elements for significant returns. To guarantee quality seed flexibly, BRAC, one of the largest Non-Government Organization (NGO) in South Asia, has been showcasing half and half maize seeds since 1994, and half and half rice seeds since 1998. It likewise began delivering crossover maize seeds in 1996-97, vegetable seeds in 1996, and crossover rice seeds in 2001. BRAC has set up the esteem chain arrangement of creation what's more, circulation for seeds and other horticultural sources of info, permitting the venture to offer reasonable costs to the ranchers. BRAC Seed what's more, Agro Enterprise centers on providing quality agrarian inputs, suitable creation what's more, present gather advancements on upgrade creation and diminish present gather misfortunes on advance the benefit of poor and negligible ranchers.

Furthermore, it is essential to BRAC to utilize manageable techniques, so that agrarian advancement doesn't happen at the expense of climate congruity [15].

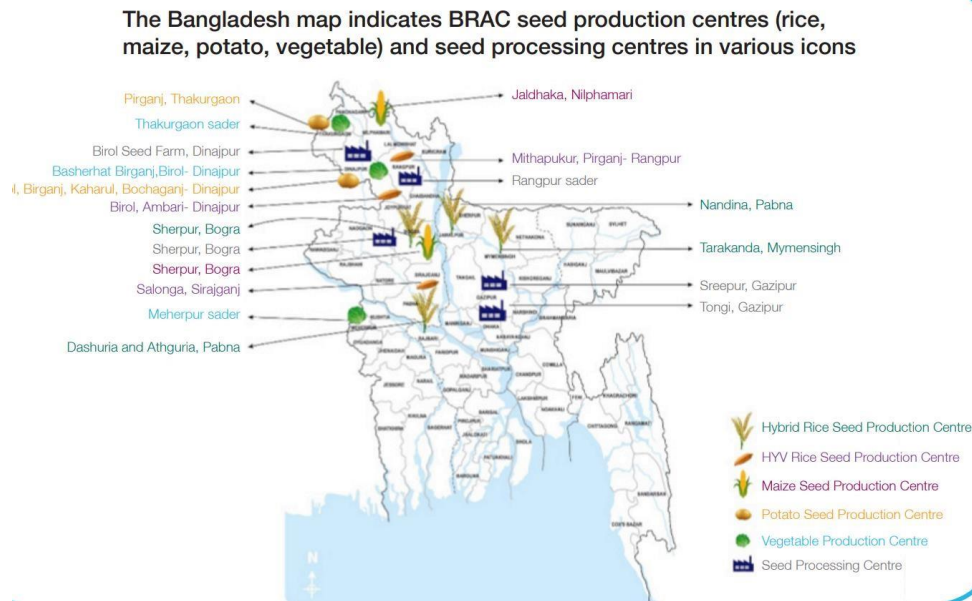


Figure 2.3.1: Seed Production Centers of BRAC [15]

BRAC Seed and Agro Enterprise has three farming examinations and improvement focuses in Gazipur, Bogra (Sherpur) and Dinajpur (Birol). The focuses are directing applied research on plant tissue culture, vegetables, rice and maize. It has a dirt testing lab with the limit of testing around 3,000 soil tests every year. Our scientists zero in on finding new assortments that address the issues of both local ranchers and purchasers. BRAC has created five half and half rice assortments, four half and half maize assortments, 10 half breed vegetable assortments and three open-pollinated vegetable assortments. It has enrolled 12 half and half rice outlandish assortments through government specialists [15].

### 2.3.2 Seed Quality Tracing

Quality of seed is an important aspect to consider for high yield production. Quality seed has the ability to actively engage in the consumption of fertilizer and irrigation systems to produce high yield crops. It is very important to trace the quality of seed through the production process and using technology to help determine the production and quality of crops in the entire supply chain of crop production.

Innovation in horticulture is ceaselessly developing. Detect ability enables the buyers as well as agri-organizations to follow the historical backdrop of starting point, taking care of, and different advances engaged with the bundling of the seed. Confirmed items have begun picking up energy as the present buyer knows. Any individual who can bear the cost of food needs to be very much educated and master everything about what they burn-through. Following the family of seed planted to check the wellspring of inception of seed is the beginning stage and has helped agri organizations keep up trust and straightforwardness [16].

Low and misleading quality seeds which can't be followed straightforwardly sway ranchers' pay also. It is fundamentally in light of the fact that the agri-organizations don't know where the seed and produce are originating from. With digitization and discernibility in the seed business, there will be full-confirmation proof of the quality which will thus prompt greater costs, which means better profit for the ranchers. As of late, numerous such tricks have surfaced where the state horticulture office has gotten a great many grumblings from ranchers, whose soybean seeds have purportedly neglected to sprout. The decision courts at that point made the seed creation organizations subject to legitimate activity and furthermore guaranteed to swap the seeds for the ranchers [16].

## **2.4 Blockchain in Traceability**

Detectability or traceability, otherwise called the guideline of "one stage back one stage forward", is the capacity to review all the data about the source of a food item. Another meaning of detectability, given by the International Organization for Standardization (ISO) in ISO 22005:2007, is the "capacity to follow the development of a feed or food through determined stage(s) of creation, preparing and conveyance" [17]. The European Union General Food Law EC 178/2002 characterizes detectability as the capacity, in all creation, handling and deals stages, of following and following the food [18]. A diagram of the item and data streams in a common recognizability framework is portrayed in Figure 2.4.1.

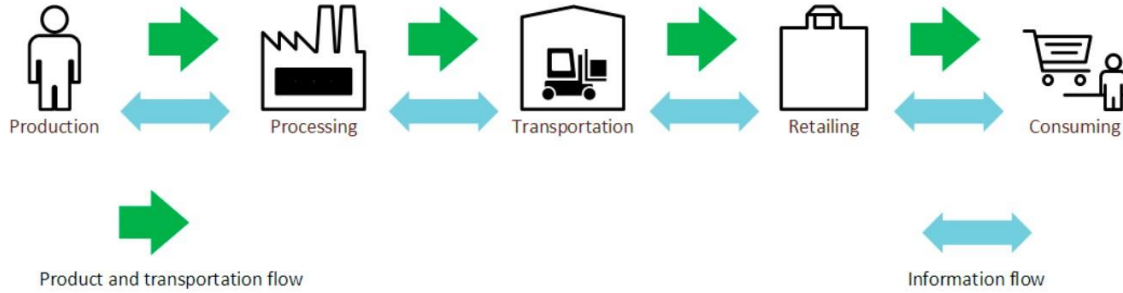


Figure 2.4.1: Agri Production Traceability Information Flow [18]

Considering all the above mentioned, food item discernibility contains data about the food fixings, the food sources, preparing just as transportation and capacity conditions. An ideal horticulture detect ability framework would likewise contain data about every single element of the end result. Along these lines, to be viewed as powerful, a recognizability framework must contain data, both quantitative and qualitative, about the last food item and its source. As indicated by A. Corallo et al., there are four significant inquiries that should be addressed with respect to the improvement of a detectability framework [19].

Another arrangement with respect to the detectability level has been performed by the European Network market, which recognizes the compulsory discernibility and the willful detectability [19]. The required recognizability mostly has to do with budgetary purposes and needs definite data about the items with respect to quality angles. Advantageous to obligatory discernibility, willful discernibility alludes to the capacity of each entertainer on the flexibly chain to openly choose what information to accumulate [19]. Defending its name, intentional recognizability isn't necessary for partners to execute. Dependable and complete recognizability is just conceivable when both compulsory and intentional detectability measures exist. Partners engaged with the flexibly chain empower a more point by point and qualitative discernibility framework when they deliberately add data. A primary test for intentional frameworks lies in their intricacy, since each entertainer may have their own principles and techniques for following and following an item, prompting a wide assortment of procured information [19].

### **2.4.1 Traceability Tools and Technology**

Early following and discernibility frameworks utilized laborers to record the data on the field and afterward physically move them on handbooks or into a PC framework. This strategy involves hazards, for example, defective data recording just as wasteful asset use. In the last ongoing many years, there is a fast advancement of mechanized cycles and items, just as in correspondence advancements, coming about in the purported Internet of Things (IoT) worldview. This fast development of IoT and sensor innovation favors the information gathering methodology by offering quick and dependable strategies. These techniques incorporate innovation for item distinguishing proof, fixing investigation, transportation, stockpiling, just as data catches all through the general framework coordination. Techniques, for example, scanner tags, QR codes, RFID, remote sensor organizations (WSNs) are the most inescapable furthermore, notable among flexible chains.

Because of their qualities, RFID frameworks give a sheltered data and information the executives framework of agri-nourishment for makers, wholesalers, retailers and customers. RFID innovation contributes in agri-food flexibly chain the executives by following and observing the "from homestead to fork" course. When a sanitation issue happens, its source and therefore the arrangement can quickly be found [20,21].

As the food flexibly chain is amazingly intricate and, simultaneously, purchaser needs and mindfulness for new, protected and quality food are persistently developing, detectability frameworks offer numerous points of interest, remembering the reduction for the time expected to review and pull out items hazardous for the general wellbeing, subsequently improving customers' security and certainty. Moreover, recognizability gives the horticulture gracefully chain with straightforwardness and unwavering quality, characteristics of utmost significance considering the multifaceted nature of the food gracefully chain these days.

### **2.4.2 Blockchain and Traceability**

Blockchain is additionally an unchanging computerized record, implying that in the event that anybody attempts to alter or degenerate the information of a particular square, hence changing the hash of this square, this will bring about a cryptographic connection interruption, because of the utilization of various hash(es) between the connected squares of the chain. In light of the adjustment in a square in the chain, all the squares after that will not, at this point be legitimate, which implies that it will not, at this point, be associated with the chain.

In Blockchain, changes in blocks are controlled using distributed peer-to-peer (P2P) networks which are the key components of Blockchain technology. In the Blockchain P2P network, a block of chain can be synchronized to ensure transparency and integrity. Every block in Blockchain consists of four major fields: (1) the number of the block, (2) the stored data or transaction, (3) the hash of the previous block and (4) the hash of the current block. The hash is created using SHA256 hashing algorithm to give an identity of each block uniquely.

The early electronic traceability systems were centralized solutions based on databases and data import conducted either in a manual or semiautomatic way. Gandino et al. propose a framework consisting of RFID tags attached on products in a fruit warehouse [22]. The proposed system is a semiautomatic RFID-based traceability platform which was designed in order to test and evaluate the effectiveness and the potential improvement of traceability using automation improvements.

Specifically, the experimental system uses RFID tags for reading products' attributes, RFID readers in order to obtain the data from the tags, personal digital assistant (PDA) devices for the personnel, so they could read the RFID readers, and a central computing system with a central database where the obtained data from the RFID tags on products are stored. This specific case study revealed that the application of RFID technology on agriculture traceability can provide many advantages and improvements, such as shorter time for data management and analysis

Corrado Costa et al. made a survey on RFID and agri-food gracefully chain discernibility in [23], in which the focal points and the potential difficulties with respect to the use of RFID innovation in the food flexibly chain are elaborately introduced. Moreover, a calculated thought of a cloud-based farming discernibility framework is planned as a future work proposition. From that point forward and keeping in mind that the blockchain innovation has been increasingly more ground in information science, the main thoughts and proposition for cloud detectability frameworks utilizing DLTs began to be detailed.

Feng Tian in a research work proposes a progressive thought regarding a framework dependent on RFID and blockchain innovation for Chinese agri-food markets with the point of improving their sanitation and quality, just as diminishing misfortunes during strategic cycles [24]. Tian's work is one of the most referred to in the writing with respect to blockchain applications in the farming area. As indicated by Tian, RFID and blockchain innovation are utilized to ensure sanitation and quality all through the whole flexible chain. The paper inspects two kinds of farming items: (I) new leafy foods, and (ii) meat, for example, pork, chicken and hamburger. The proposed network uses the highlights of blockchains so that everything partners can approach each exchange and data with respect to a particular item. The fundamental point of Tian is to cover the entire cycle of information assortment and data of the executives, for each exchange between the partners in the farming flexibly chain. The whole framework gives checking, following and following of the nature of agri-food and can be described as a "homestead to fork" arrangement. Tian's answer presents the two points of interest and difficulties (thinking about cultural, money related and specialized perspectives) contrasted with brought together arrangements [22].

Arsyad et al. [25] propose a structure that utilizes a two-way factor confirmation blockchain arrangement and what's more, watermarks pictures and records utilizing the discrete wavelet change technique. Hayati et al. [26] present the FoodTrail stage, which utilizes a four-layer design related to shrewd agreements as an approach to direct exchanges through the entire graceful chain. In the exact year, the World Wildlife Asset (WWF) made an



undertaking called "Snare to-plate" zeroed in on the discernibility of fish in New Zealand all through the entire graceful chain. WWF's undertaking embraces RFID advancements for fish labeling and an Ethereum-based blockchain [27].

In the review of the above articles, it has been found that seed quality traceability is still an emerging issue and still at infancy in terms of adoption of technology based solutions using Blockchain and IoT. The proposed research work will be in the direction of seed quality traceability using Blockchain and using a framework driven through the production process.

### **2.4.3 Ethereum and Smart Contracts for Consensus**

Ethereum, a Blockchain project platform created in the year 2013 by Vitalik Buterin, is a decentralized platform to facilitate Blockchain based business transactions using smart contracts. The "decentralized platform" part implies that anybody can set up and run an Ethereum hub, a similar way anybody can run a Bitcoin hub.

Any individual who needs to run a "brilliant agreement" on the hubs needs to pay the administrators of those hubs in Ether, which is a cryptographic money token attached to Ethereum. Hence, individuals who run Ether hubs give registering power and are paid in Ether, along these lines to how individuals who run Bitcoin hubs give hashing power and are paid in Bitcoin. As it is defined, smart contracts inherit some important attributes such as immutable and distributed because of the storage inside the blockchain. Due to immutability which ensures that no one can tamper with the code of the contract, while being distributed and secures the validation of smart contracts output from everyone on the network. As of now, smart contracts have been used in many types of blockchain applications such as in supply chains and in the health sector.

In a broad sense, smart contracts are computer programs that can automatically execute the terms of contract defined within the scope of the solution using Blockchain. When a predefined condition in a smart contract among contributing entities is met then the parties

involved in a contractual agreement can automatically make payments as per the pre-mentioned conditions in contract in a transparent manner.

#### 2.4.4 Private and Public Blockchain

Public blockchain networks are portrayed as permissionless, where anybody can join, perused or potentially compose information, make keen agreements or even run a hub inside them, guaranteeing 100% straightforwardness just as a significant level of secrecy. Public organizations are suggested for substances engaged with crypto-financial matters. Interestingly to public blockchain networks, private organizations confine either member or validator access as an exemplary shut biological system where all companions are all around characterized and just pre-approved substances can run hubs. Following a business-to-business approach, numerous organizations utilize private blockchain networks to profit by this innovation without relinquishing their self-rule. Private blockchains, in differentiation to public ones, commonly utilize a sort of agreement other than PoW (Proof of Work), and might target keeping certain data private from the general population. In outline, public blockchain networks appreciate opportunity in decentralization, though private blockchain networks appreciate opportunity in configurational adaptability [21].

Half and half methodologies additionally exist—these are called permissioned blockchain frameworks. Various flavors of what's more, designs of permissioned blockchain frameworks exist, however commonly the agreement cycle is constrained by a predefined rundown of members, and clients can't take an interest without consent. Admittance to the full data of exchanges on the blockchain may be limited, contingent upon the client job.

Table 1: Use of different blockchain type and implementation

| <b>Public / Private Blockchain</b> | <b>Implementation Platform</b>                  |
|------------------------------------|---|
| Public                             | Ethereum<br>Hyperledger Sawtooth<br>Hyperledger |

|         |                                  |
|---------|----------------------------------|
| Private | Etherium<br>Hyperledger<br>Mixed |
|---------|----------------------------------|

The Table 1 shows the different platforms which could be utilized in traceability applications.

## 2.5 Blockchain Architecture for Agriculture

Different researchers worked and are still working in the area of implementing Blockchain for Agriculture and a huge pool of resources are in the experimental stage for bringing Blockchain based solutions for quality food production. One such model is shown below as worked out by researchers Kaijun et.al. [28].

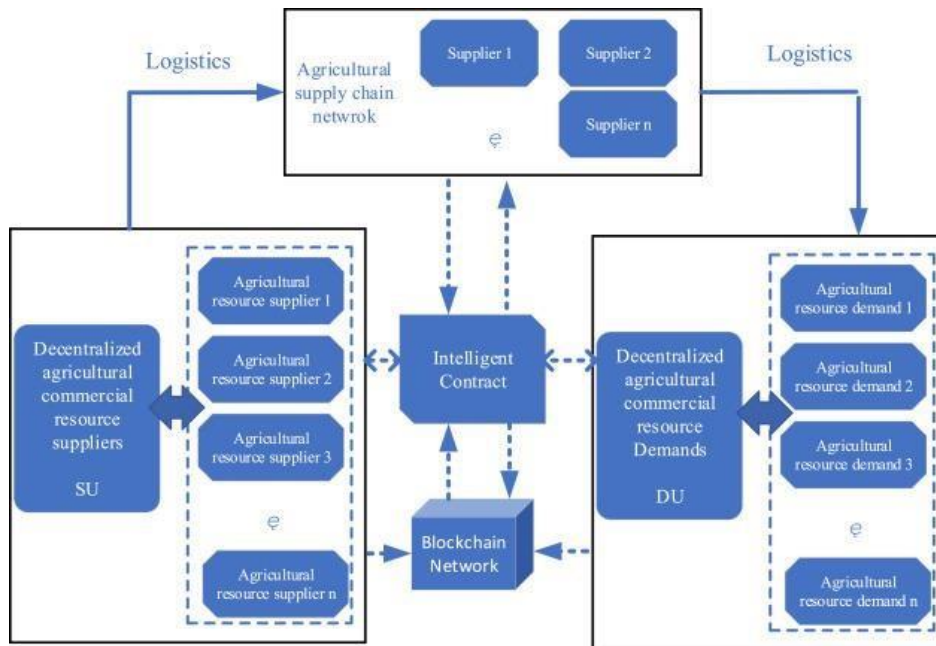


Figure 2.5.1: Blockchain Framework in Agriculture Supply Chain [28]

As seen from a proposed research work in Figure 2.5.1, within the agriculture supply chain network, there are many suppliers and suppliers are associated with logistics. The logistic unit is composed of decentralized agriculture commercial resource suppliers having

connected with smart contracts which are within the blockchain network at the heart of the framework. Both the suppliers and agriculture resource suppliers are interconnected through the smart contract with the blockchain network.

## CHAPTER 3 PROPOSED FRAMEWORK

### 3.0 Introduction

The business process model of seed production process plays a vital role in the formation of an approach to apply Blockchain for quality control and management of seed. A typical production process is shown in the following Figure 3.0.1.

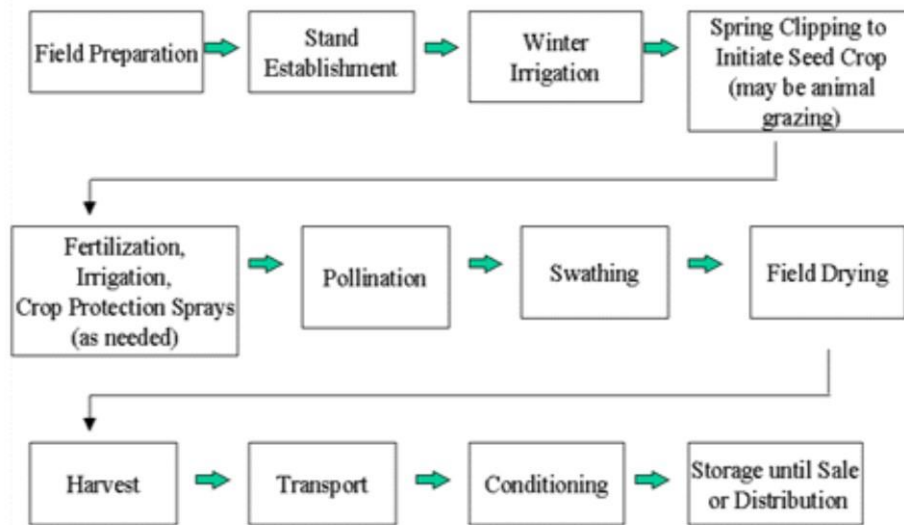


Figure 3.0.1: Typical Seed Production Process

As seen in Figure 3.0.1, the seed production begins with field preparation with necessary fertilizer and irrigation process. Once the stand is ready, and after the winter or seasonal irrigation, followed by fertilization, the pollination begins. Pollination goal is to create offspring for the next generation. One of the ways that plants can produce offspring is by making seeds. After pollination, swathing takes place which processes the crops for the

preparation of seeds. Once drying in the field, it gets ready for the harvest and transportation to storage for conditioning and thereafter the distribution to farmers in the field.

In the formation of a framework based on Blockchain, necessary transformation of the business process shown in Figure 3.0.1 is necessary to ensure the traceability of seed for the quality production.

### **3.1 Proposed Framework for Seed Quality Tracing**

In the formation of the proposed framework for seed quality tracing using Blockchain, the following considerations and constraints have been made based on the typical seed production process shown in the Figure 3.0.1:

- a. Pre-production Phase: consisting of field production, stand establishment, fertilizer, irrigation and protection spray
- b. Production Phase: consisting of stages covering pollination, swathing, field drying and harvest
- c. Post-Production Phase: consisting of transport, conditioning and distribution of seeds

The different nodes of the proposed framework for seed quality tracing based on Blockchain is shown in the following Figure 3.1.1.

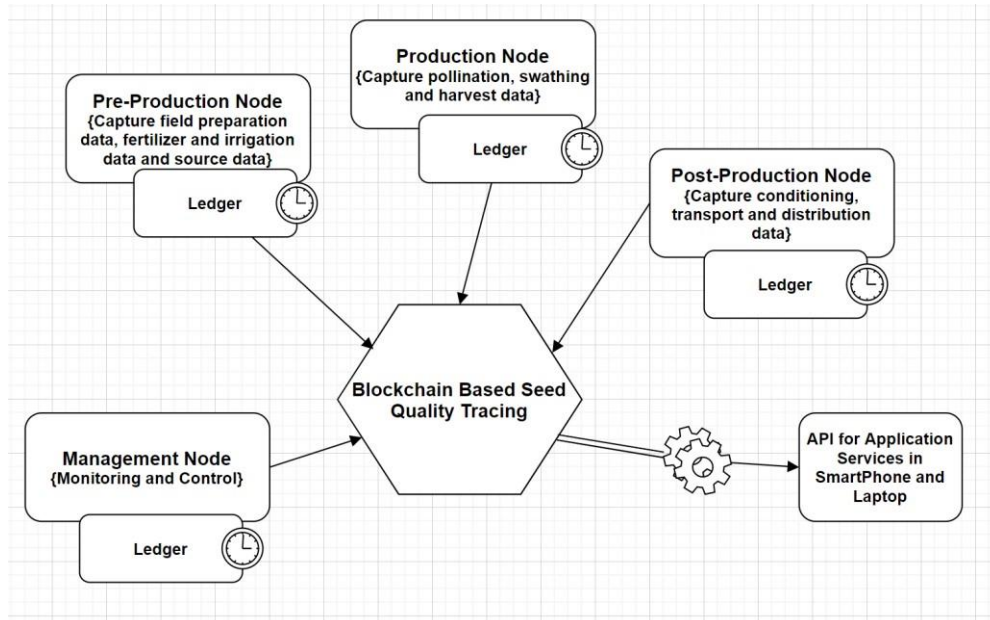


Figure 3.1.1: Nodes in Proposed Blockchain based seed quality tracing

Based on the design constraints, as shown in the Figure 3.1.1 the proposed framework for seed quality tracing based on Blockchain will consist of three categories of nodes: (1) Pre-production nodes: responsible for collecting data related to pre-production phase of the seed production which includes field preparation, fertilizer and irrigation with crop protection data; (2) Production nodes: responsible for collecting data related to pollination, swathing and harvest with specific filtering of seeds; and (3) Post-production nodes: responsible for collecting data related to storage, conditioning and distribution till the field levels. Every node carries its own ledger to reflect specific seed production identity and ensure transparency among the parties. The management node governs the Blockchain data sharing and distribution management. The core Blockchain network will be enabled with Application Programmers Interface (API) to support application development both for the smartphone and laptop and interacting with Internet gateway.

The proposed system architecture is shown in the following Figure 3.1.2.

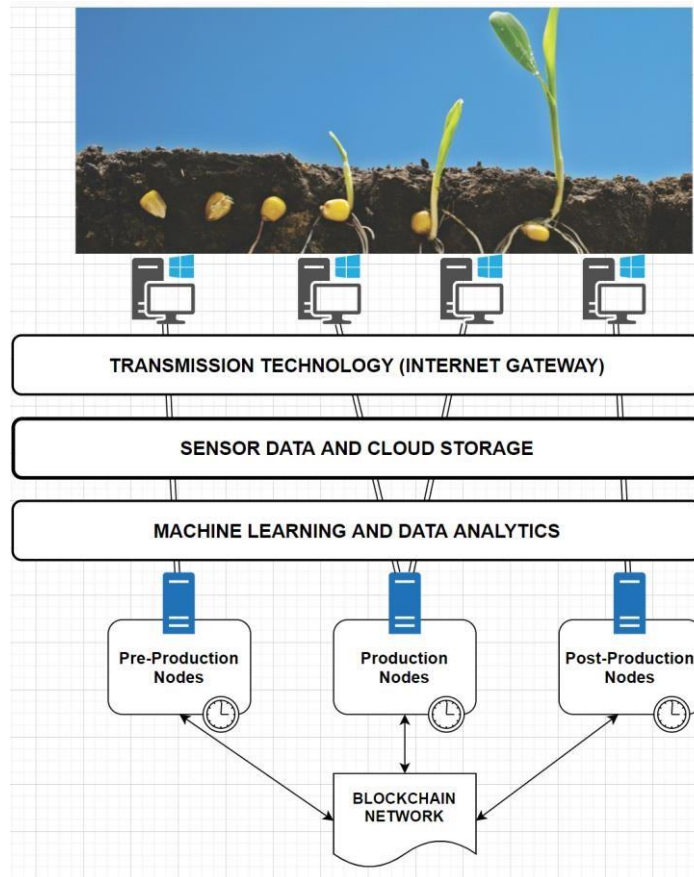


Figure 3.1.2: Proposed Blockchain based seed quality tracing system architecture

As shown in Figure 3.1.2, the proposed system architecture consists of nodes responsible for pre-production, production and post-production stages in association with the Blockchain network. The top most layer of the proposed system architecture is connected to the Internet gateway to enable API interactions with the digital services through smartphone and web application. The different sensors used in the tracing of seed quality that generate data at the sensor data and cloud storage layer. These data will be utilized for necessary data analytics using machine learning techniques.

### 3.2 Conceptual Interaction Model

The conceptual interaction model for the proposed seed quality tracing architecture is shown in the Figure 3.2.2.

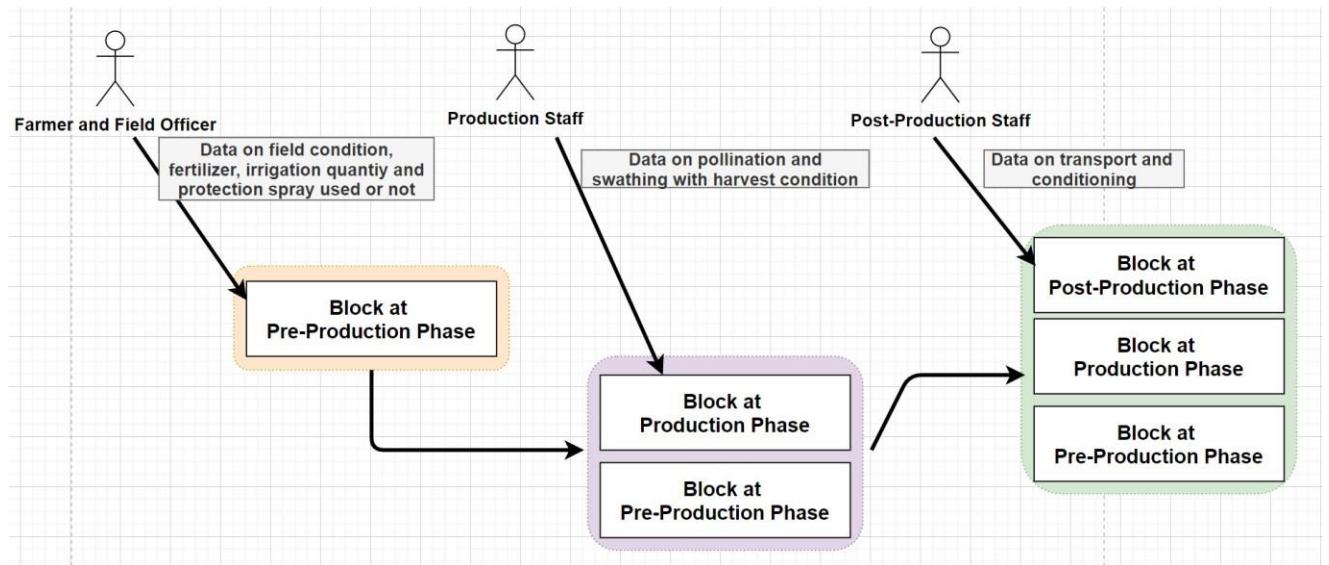


Figure 3.2.2: Conceptual Interaction model of the Proposed Blockchain based seed quality tracing system

As seen from the interaction model in the Blockchain network, starting from Farmer and field officer upon capturing data on field condition, fertilizer used and irrigation, the initial block is created at the pre-production node and this is broadcasted in the seed blockchain network. Soon this information is boardasted in the Blockchain network, different stakeholders including production and post-production are notified. The next block is added by the Production staff and it captures data on pollination and swathing. This enables detailed information on seed production quality. After this second stage, the next block is added in the Blockchain network by Post-Production staff and this block captures data on transportation and conditioning. At any point in time, the stakeholders in the network are aware of the seed production quality and stages.

### 3.3 Framework Components

The proposed framework for seed quality tracing based on Blockchain as elaborated in the sections 3.1 and 3.2 demands well defined components for ensuring growth and continuity. The different components of the proposed framework are:



- a. *Pre-Production Component*: Nodes and sensors dedicated to Pre-Production phase in order to capture data related to irrigation, fertilizer, field conditioning and area. Besides, usage of insecticide and other protection control is also recorded
- b. *Production Component*: Nodes and sensors dedicated to production phases will be responsible to gather data related to pollination and swathing along with other associated processes as required for quality tracing.
- c. *Post-Production Component*: Nodes and sensors dedicated to the post-production phase will be responsible for collecting data related to conditioning and transportation.
- d. *API Interaction Component*: Nodes responsible to provide data analytics and quality tracing services based on the Blockchain network with the help of application programming interface (API) to be used in mobile apps and web applications for the public usage.

### **3.4 Implementation Challenges**

The proposed framework for seed quality tracing using Blockchain implementation has some rigorous challenges as the data primarily requires engagement of farmers and is vastly dependent on the field level. The following key challenges lies in the successful deployment of the proposed framework for seed quality tracing using Blockchain:

- (a) *Sensor based data collection for irrigation and fertilizer*: this challenges lies with the appropriate selection and/or development of sensor based data acquisition module to facilitate automatic or semi-automatic data collection in the preproduction, production and post-production phases
- (b) *Deployment of intelligent nodes at the field level*: this challenge lies with the appropriate design of the Blockchain network based on field condition and using sustainable technology

- (c) *Education of farmers for quality seed tracing application usage*: this challenge lies with the education of farmers in using mobile apps or web applications to identify seed quality parameters before sowing in the field
- (d) *Adaptation to Technology change*: this challenge lies with the adaptation of technology change in order to ensure scalability and growth over the time

## **CHAPTER 4 SIMULATION OF PROPOSED FRAMEWORK**

### **4.0 Introduction**

There are top platforms designed for implementation of Blockchain based solutions. Top giants like IBM and Amazon contributed a lot in making this happen. As one of the younger blockchain environments, IOTA took to the blockchain landscape with a mission to fundamentally change the way that people access distributed ledger technology. The target is to ensure a more secure environment for exchanging values and data without fees. Though IOTA doesn't actually use any chains or blocks, and is instead powered by its own unique technology. Another platform called OpenChain is a public blockchain platform

developed by Coinprism. This powerful environment helps companies create information systems for experimentation.

Another very known implemen Hyperledger Sawtooth is a blockchain offering made available from the Linux foundation. The Sawtooth is a modular enterprise-grade platform where experts can create, deploy, and execute distributed ledgers. Another popular platform called Ethereum is also a blockchain platform. Since 2013, Ethereum has offered blockchain developers an open-source distributed computing platform where application blockchain can be deployed. With the use of Ethereum, one can write codes using the Ethereum Virtual Machine run-time environment. IBM also has offered an exciting blockchain platform called HyperLedger, which offers more transparent environments for company operations. Using IBM Blockchain Hyperledger, companies can better redefine their business relationships through trust, transparency, and newfound collaboration.

In this research work, ChainRider, a platform designed to test blockchain solutions as part of the Proof of Concept (PoC) is used for prototype experiments. In the context of Blockchain, ChainRider offers an unique ecosystem of tools and services built around public and private blockchain which help to develop, prototype and build proprietary applications on the blockchain in a fast and simple manner. This PoC is to ensure the working of the proposed solution of seed quality tracing using blockchain.

#### **4.1 Simulation of Proposed Framework**

The chainrider.io is an open platform and the following process and user interfaces displays the formulation of the prototype for the proposed solution.

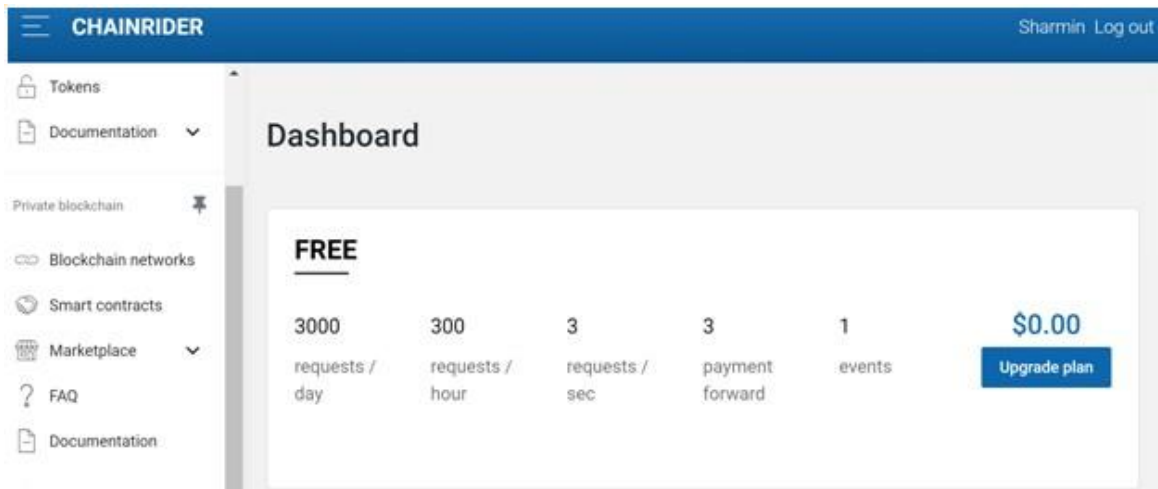


Figure 4.1.1: Web front end of Chainrider Blockchain Platform

As seen from Figure 4.1.1, the Chainrider framework provides blockchain prototype development on the top of Hyperledger fabric. The web front end show the necessary tools to create a Blockchain network, smart contracts and also export the network for use in the production platform to serve the marketplace.

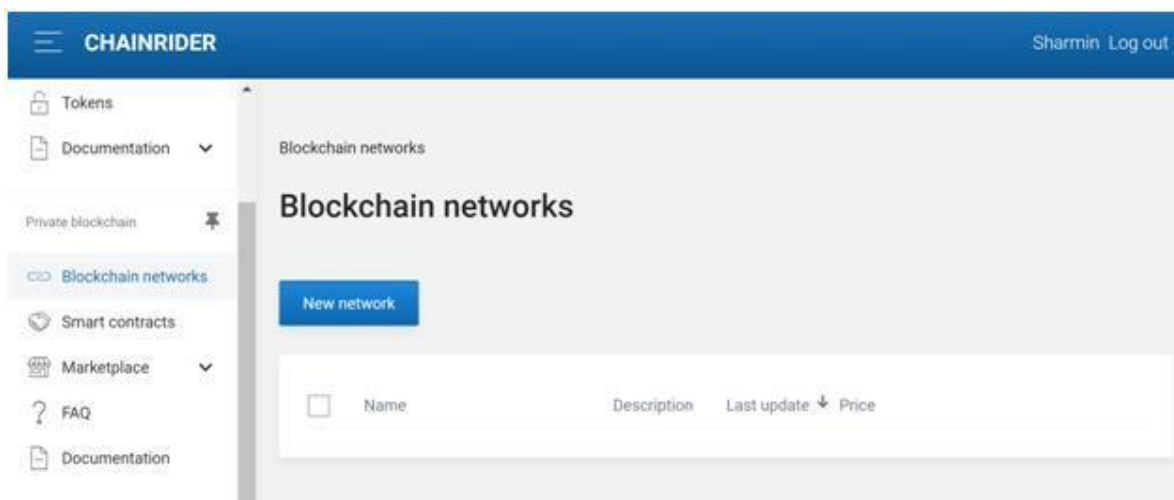


Figure 4.1.2: Web front end for Blockchain network in Chainrider Blockchain Platform

The new blockchain network creation in Chainrider is shown in Figure 4.1.2. The new network needs detailed description of organization, services, peers and machine

interactions in peers for the network to function. The seed quality tracing blockchain network is created and shown in Figure 4.1.3.

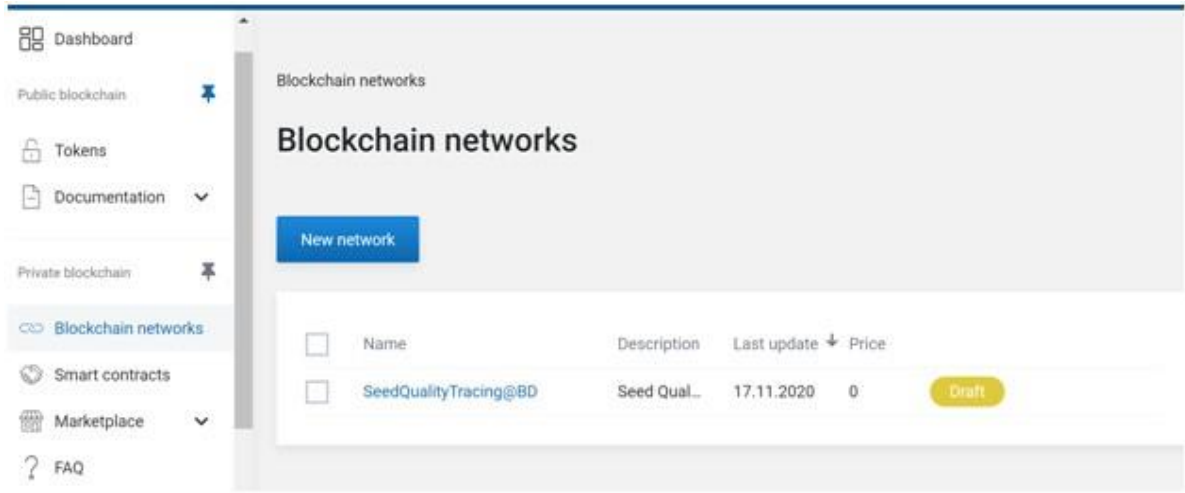


Figure 4.1.3: Web front end for Blockchain network after creation of SeedQualityTracing in Chainrider Blockchain Platform

The seed-to-serve-diu block chain network with its parameters is shown in the Figure 4.1.4 below.

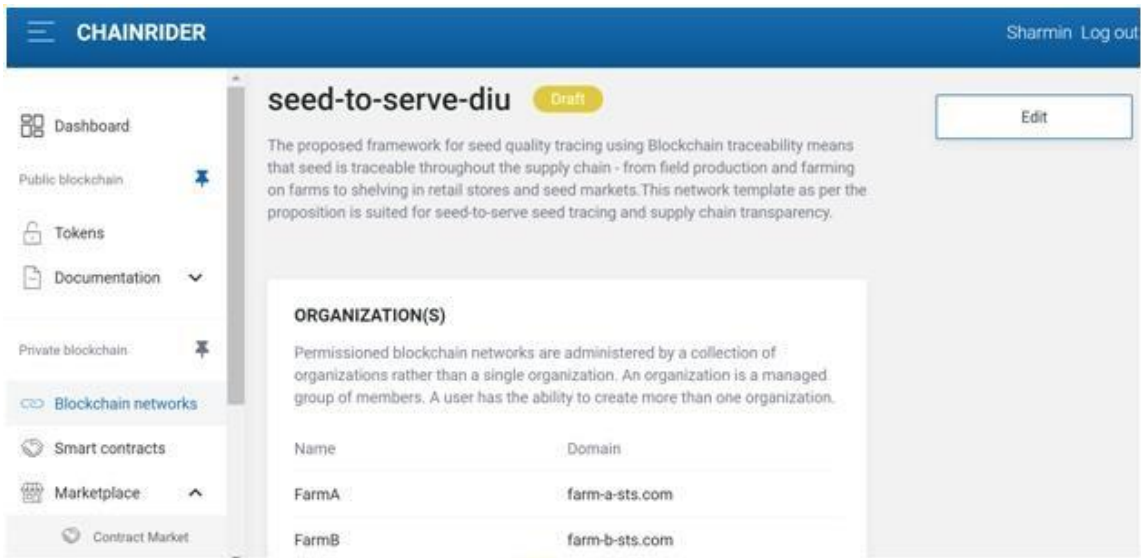


Figure 4.1.4: Web front end for Blockchain network seed-to-serve-diu in Chainrider Blockchain Platform

The different channels for pre-production, production and post-production are created for the transaction services in blockchain network and shown in Figure 4.1.5.

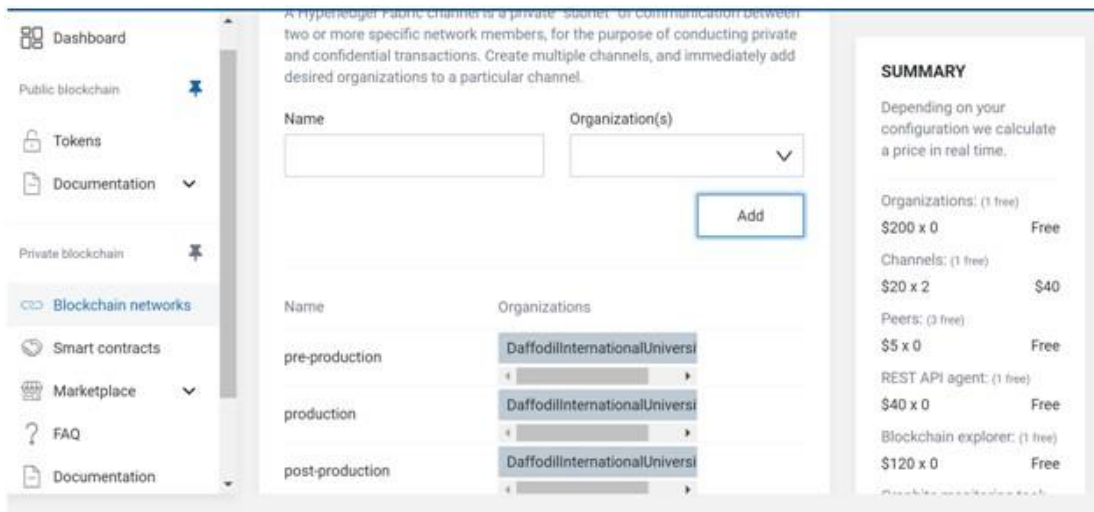


Figure 4.1.5: Web front end for different channels in Blockchain network for seed tracing in Chainrider Blockchain Platform

In every channel based on seed production business process including pre-production, production and post-production, peers are created as a representation of node in the blockchain network. The pre-production channels are shown in Figure 4.1.6.

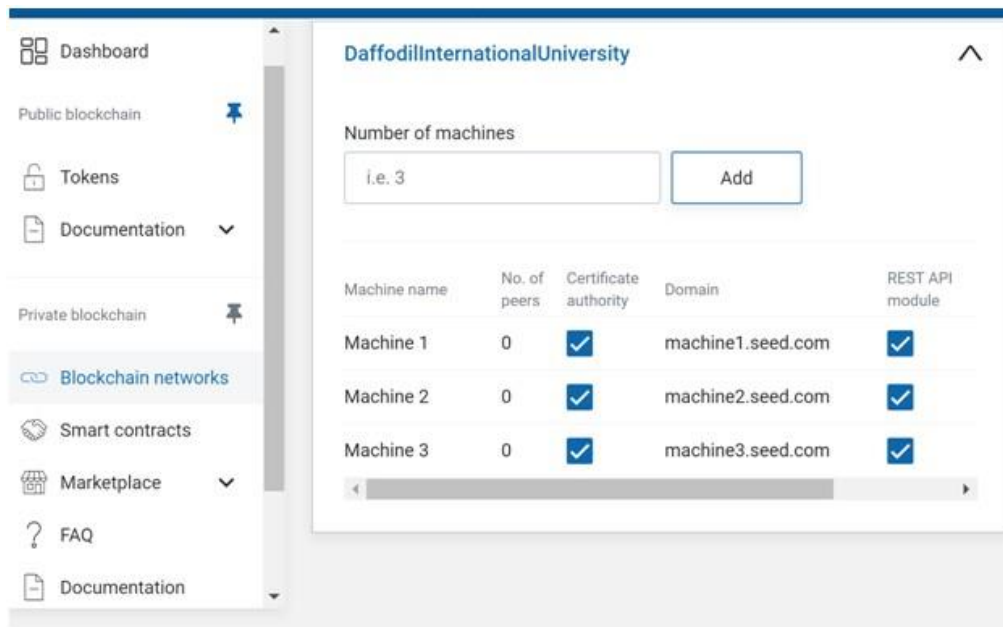


Figure 4.1.6: Web front end for peers in pre-production channel in Blockchain network for seed tracing in Chainrider Blockchain Platform

Once the blockchain network is created in Chainrider, the entire files are exported to production server for real-life deployment. The summary snaps shots are shown in Figure 4.1.7.

## SeedQualityTrace@BD

Draft

The proposed framework for seed quality tracing using Blockchain traceability means that seed is traceable throughout the supply chain - from field production and farming on farms to shelving in retail stores and seed markets. This network template as per the proposition is suited for seed-to-serve seed tracing and supply chain transparency.

## ORGANIZATION(S)

Permissioned blockchain networks are administered by a collection of organizations rather than a single organization. An organization is a managed group of members. A user has the ability to create more than one organization.

| Name           | Domain                  |
|----------------|-------------------------|
| PreProduction  | preprod.seed.com        |
| Production     | production.seed.com     |
| PostProduction | postproduction.seed.com |

## CHANNELS

A Hyperledger Fabric channel is a private "subnet" of communication between two or more specific network members, for the purpose of conducting private and confidential transactions. Create multiple channels, and immediately add desired organizations to a particular channel.

| Name           | Organization(s) |
|----------------|-----------------|
| fertilizer     | PreProduction   |
| irrigation     | PreProduction   |
| harvesting     | PreProduction   |
| pollination    | Production      |
| swathing       | Production      |
| conditioning   | PostProduction  |
| transportation | PostProduction  |

Figure 4.1.7: Web front end for seed tracing in Chainrider Blockchain Platform

## 4.2 Operational Aspects

The operational aspects of the defined blockchain network from Chainrider entirely depends on the hyperledger framework and peer-to-peer network nodes. Once the network is created in Chainrider, the downloaded network can be deployed in the production platform. Each of the channel with its associated peer in the downloaded source will be configured accordingly. The expected target platform will be Unix 64bit architecture with



1GB RAM. As part of the software components nodejs, docker, docker compose, gcc and other compilers will be required. During the deployment of the blockchain network, the orderer service will be deployed first in association with the domain and port. After the orderer service has been deployed successfully, the machine or peer will be deployed in connection to the domain. ChainRider adds machine name as a subdomain meaning the entire domain name for a machine will be machine{N}.{domain\_you\_have\_specified\_for\_that\_machine}. The final step in the deployment is setting up REST (REpresentational State Transfer) API for the application services.

### **4.3 Simulation Results**

The simulation of the proposed framework for seed quality tracing using Blockchain is created using Chainrider based on hyperledger fabric and different actors based on the business process model of seed production is created in the blockchain network. The proposed framework for pre-production, production and post-production phases of seed is formulated as an organization unit , each organization unit has channels based on the action unit of pre-production, production and post-production phases has peers associated based on domain. The prototype blockchain network is simulated in Chainrider.

## **CHAPTER 5 DISCUSSION AND CONCLUSION**

### **5.1 Discussion**

In this research work, we tried to look at through understanding of blockchain with detail on how to create a blockchain network. The different architecture of blockchain networks along with the application of blockchain in developing business solutions is also addressed. The proposed topic of seed quality tracing using blockchain is an utmost importance to national productivity and food security. The investigations were carried out to develop insights on using blockchain for seed quality tracing and respective challenges. Alongside the seed quality tracing, framework understanding based on seed production process is investigated for necessary transformations in creating a framework for blockchain network.

### **5.2 Conclusion**

In the formation of the proposed framework for seed quality tracing using Blockchain, through investigation is carried out to develop a clear understanding of Blockchain, blockchain architecture and application design based on blockchain. Different approaches are studied to develop insights on seed quality tracing based on the business process model of seed production and management. The conceptual framework for seed quality tracing is developed based on seed production process and requirements for seed quality issues. The conceptual framework including the system architecture is proposed for the seed quality tracing. The proof of concept (PoC) is carried out in Chainrider through creation of a blockchain network.

### **5.3 Future Work**

Due to limitations of time, implementation of the proposed framework in a production environment is out of the scope of this work. The future work based on the proposed framework for seed quality tracing using blockchain are as follows:

- a. Implement the seed\_quality blockchain network in a production environment
- b. Integrate sensors and data acquisition modules in the blockchain network for functional data exchange for quality tracking
- c. Incorporate artificial intelligence (AI) to improve decision making of quality seed
- d. Incorporate field level tracking of seed production

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### CHAPTER 1 INTRODUCTION

#### 1.0 Introduction

With the rapid transformation in this pandemic time and Industry 4.0, Blockchain, Bitcoin and smart contracts have grown with the enormous popularity and industry adoption grown on a different scale. As we also realized that blockchain technology has become the biggest invention since the Internet, because it can disrupt many sectors, make processes faster and lower transaction costs with transparency. Along with this dramatic growth of Blockchain primarily due to digital currencies based on blockchain technology which is also valued.

Blockchain revolution started back in the year 2009 with an alternative currency called Bitcoin, came-up with a famous research proposed by Satoshi Nakamoto [1], that is issued and governed by a consensus system defined within the nodes connected and among users from the network. The electronic cash in the form of Bitcoin can be exchanged through the Internet in a decentralized, trustless system which deploys a public ledger known as Blockchain [2]. In the process of transactions, the component Blockchain is going to modify the way data is stored and connected in the connected nodes of a decentralized network. In this process of interactions, every record gets stored in a shared and transparent database where contracts can be embedded in digital code from the decentralized network formation [3]. Within the decentralized network, the existing business transforms and relies on other associated parties challenged by the Blockchain technology [4]. It is a known case that the Blockchain is able to deploy automatic mechanisms of trust without a central monitoring authority that helps to mitigate the risks and make operations more efficient [5]. As a result of this leverage of the trust model, it empowers finance, government, supply-chain and other related services [6].

# Framework for Seed Quality Tracing using Blockchain

*by* Sharmin Akter

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# CHAPTER 1

## INTRODUCTION

### 1.0 Introduction

With the rapid transformation in this pandemic time and Industry 4.0, Blockchain, Bitcoin and smart contracts have grown with the enormous popularity and industry adoption grown on a different scale. As we also realized that blockchain technology has become the biggest invention since the Internet, because it can disrupt many sectors, make processes faster and lower transaction costs with transparency. Along with this dramatic growth of Blockchain primarily due to digital currencies based on blockchain technology which is also valued.

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In this technology era and with the rapid emergence of pandemic, a growing concern among the people of this planet embarked on living a healthy life at the face of pandemic



It is very clear that Bangladesh's national seed strategy needs a seed quality framework based on Blockchain to improve the seed quality tracing that leads to healthy living.

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Besides, with the adoption of Industry 4.0 and a rapid increase in the application of the practical and effective usage of digital ledger technology (DLT) in the agriculture supply

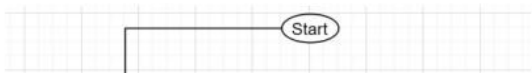


**1.3 Expected Outcome**





It has been found that during the harvest season alone, poor quality seeds hampered the







### **2.2.1 Blockchain**

Blockchain is viewed as the principle insurgency of Bitcoin. Over the years, Blockchain

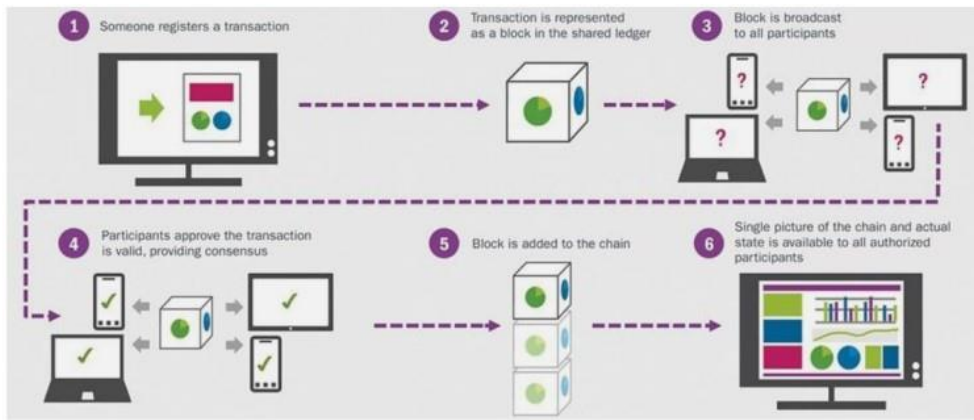


Figure 2.2.2: Working principle of Blockchain [10]

As seen from Figure 2.2.2, at the first step when someone requests or register for a transaction as shown in step-1, the transaction is represented as a block in a shared ledger shown in step-2. When the block is created, the block is broadcasted in the connected nodes to all participants as shown in step-3. The participants verified and approved the transaction through consensus mechanism shown in step-4. Once the transaction is validated, the **transaction is unalterable and the block is added to the chain** shown in step-5 and the transaction gets completed in step-6.

Blockchain misuses the possibilities of the public key cryptography, to shield the security of the tasks. Subsequently, to execute any sort of trade, the client should be appointed both a public and a private key. The entire organization knows the public one, which particularly recognizes the client in the organization. The private key is utilized to carefully sign exchanges and should be left well enough alone by the client. Along these lines, just the client who can create a substantial mark with his private key can guarantee the responsibility for exchange [11].

The correspondence is performed straightforwardly between peers, rather than utilizing a focal hub as orchestrator. Every hub of the organization stores and forward data to every other hub [12].

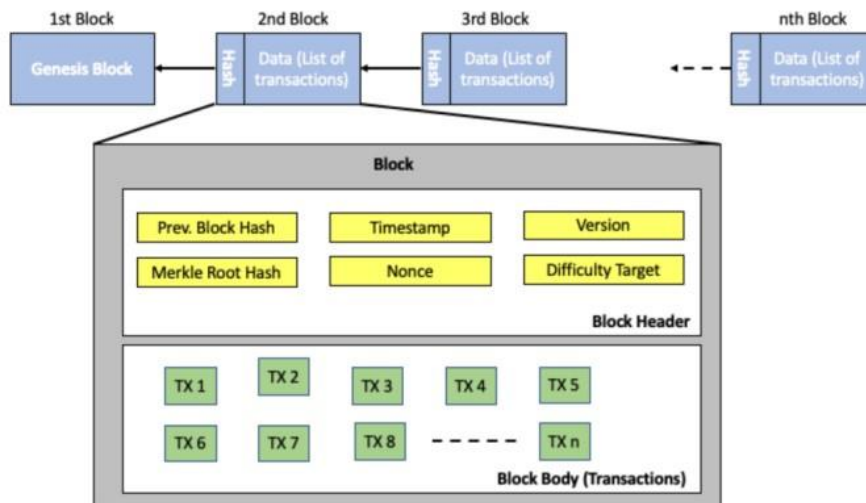


Figure 2.2.3: Example of a Blockchain containing  $n$  blocks [15]

16

As shown in Figure 2.2.3, in Blockchain, each consist of block header and block body. In block header, there are six specific piece of information; previous block hash: hash code as a reference to the blocks generated and linked to ensure each block is connected which is generated through transaction process of the users, Version: the current version of the block, Markle root hash: an encrypted hash of all transactions taking place in this block known as Merkle root hash, Timestamp: time of the creation of the block, Nonce: any random number that is assigned by a block creator that can be changed as and when required and the body containing data for the block.

Blockchain abuses the possibilities of the public key cryptography, to protect the security of the tasks. Consequently, to execute any kind of trade, the client should be appointed both a public and a private key. The entire organization knows the public one, which interestingly recognizes the client in the organization. The private key is utilized to carefully sign exchanges and should be left well enough alone by the client. Thus, just the client who can create a legitimate mark with his private key can guarantee the responsibility for exchange [10].

Another significant property of Blockchain lies in its advanced nature. This nature of the record ties the exchanges to a computational rationale that permits their programmability. Thus, it is conceivable to make decisions and calculations that trigger exchanges between hubs in a programmed way [11]. A case of this trademark are the brilliant agreements. Brilliant agreements are spoken to by PC code that is executed on the Blockchain. They work executing a bunch of predefined rules through a progression of on the off chance that does that. Along these lines, they ensure that the standards that were set up by the organization members are followed, without the requirement for a go-between [13]. In this sense, keen agreements can bring security assurance, mechanization and knowledge into a Blockchain-based framework [14]. Since brilliant agreements are actualized on the Blockchain, they acquire all the Blockchain's properties: they work in a completely computerized way, they are dispersed over the organization, and they are perpetual and carefully designed [5-7].

### **2.3 Seed Quality Tracing**

Seed quality lies with a complex production process and in Bangladesh, we have farming in different regions and divisional towns to help farmers with the seasonal crops. This section elaborates on the seed production aspects and the necessity of tracing for quality seeds.

#### **2.3.1 Seed and Agro Enterprise in Bangladesh**

Quality seeds are one of the vital elements for significant returns. To guarantee quality seed flexibly, BRAC, one of the largest Non-Government Organization (NGO) in South Asia, has been showcasing half and half maize seeds since 1994, and half and half rice seeds since 1998. It likewise began delivering crossover maize seeds in 1996-97, vegetable seeds in 1996, and crossover rice seeds in 2001. BRAC has set up the esteem chain arrangement of creation what's more, circulation for seeds and other horticultural sources of info, permitting the venture to offer reasonable costs to the ranchers. BRAC Seed what's more, Agro Enterprise centers on providing quality agrarian inputs, suitable creation what's more, present gather advancements on upgrade creation and diminish present gather misfortunes on advance the benefit of poor and negligible ranchers.

Furthermore, it is essential to BRAC to utilize manageable techniques, so that agrarian advancement doesn't happen at the expense of climate congruity [15].

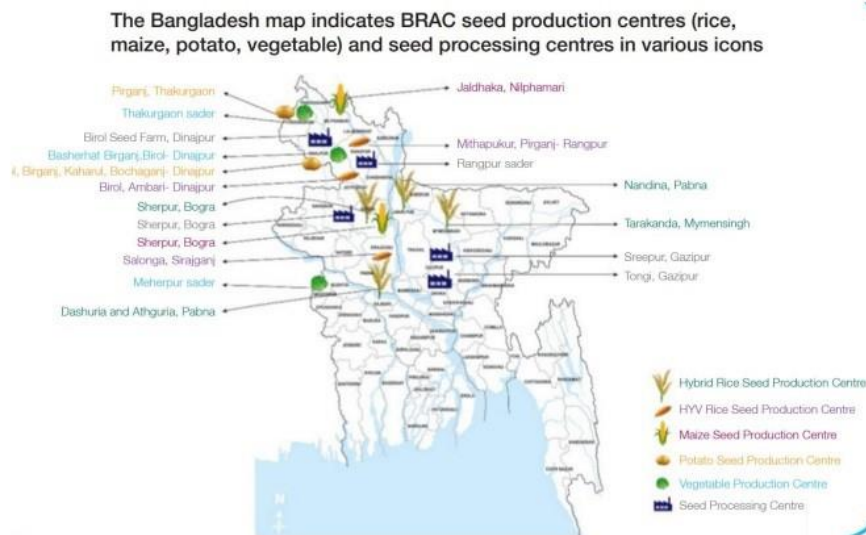


Figure 2.3.1: Seed Production Centers of BRAC [15]

BRAC Seed and Agro Enterprise has three farming examinations and improvement focuses in <sup>11</sup> Gazipur, Bogra (Sherpur) and Dinajpur (Birol). The focuses are directing applied research on plant tissue culture, vegetables, rice and maize. It has a dirt testing lab with the limit of testing around 3,000 soil tests every year. Our scientists zero in on finding new assortments that address the issues of both local ranchers and purchasers. BRAC has created five half and half rice assortments, four half and half maize assortments, 10 half breed vegetable assortments and three open-pollinated vegetable assortments. It has enrolled 12 half and half rice outlandish assortments through government specialists [15].

### 2.3.2 Seed Quality Tracing

Quality of seed is an important aspect to consider for high yield production. Quality seed has the ability to actively engage in the consumption of fertilizer and irrigation systems to produce high yield crops. It is very important to trace the quality of seed through the production process and using technology to help determine the production and quality of crops in the entire supply chain of crop production.



Innovation in horticulture is ceaselessly developing. Detect ability enables the buyers as well as agri-organizations to follow the historical backdrop of starting point, taking care of, and different advances engaged with the bundling of the seed. Confirmed items have begun picking up energy as the present buyer knows. Any individual who can bear the cost of food needs to be very much educated and master everything about what they burn-through. Following the family of seed planted to check the wellspring of inception of seed is the beginning stage and has helped agri organizations keep up trust and straightforwardness [16].

Low and misleading quality seeds which can't be followed straightforwardly sway ranchers' pay also. It is fundamentally in light of the fact that the agri-organizations don't know where the seed and produce are originating from. With digitization and discernibility in the seed business, there will be full-confirmation proof of the quality which will thus prompt greater costs, which means better profit for the ranchers. As of late, numerous such tricks have surfaced where the state horticulture office has gotten a great many grumblings from ranchers, whose soybean seeds have purportedly neglected to sprout. The decision courts at that point made the seed creation organizations subject to legitimate activity and furthermore guaranteed to swap the seeds for the ranchers [16].

## 2.4 Blockchain in Traceability

Detectability or traceability, otherwise called the guideline of "one stage back one stage forward", is the capacity to review all the data about the source of a food item. Another meaning of detectability, given by the International Organization for Standardization (ISO) in ISO 22005:2007, is the "capacity to follow the development of a feed or food through determined stage(s) of creation, preparing and conveyance" [17]. The European Union General Food Law EC 178/2002 characterizes detectability as the capacity, in all creation, handling and deals stages, of following and following the food [18]. A diagram of the item and data streams in a common recognizability framework is portrayed in Figure 2.4.1.

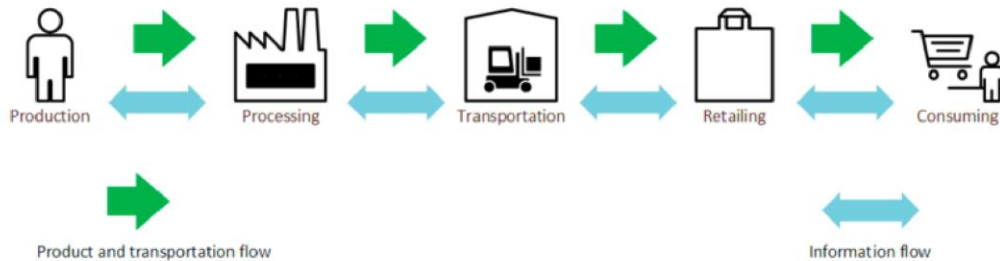


Figure 2.4.1: Agri Production Traceability Information Flow [18]

1 Considering all the above mentioned, food item discernibility contains data about the food fixings, the food sources, preparing just as transportation and capacity conditions. An ideal horticulture detect ability framework would likewise contain data about every single element of the end result. Along these lines, to be viewed as powerful, a recognizability framework must contain data, both quantitative and qualitative, about the last food item and its source. As indicated by A. Corallo et al., there are four significant inquiries that should be addressed with respect to the improvement of a detectability framework [19].

Another arrangement with respect to the detectability level has been performed by the European Network market, which recognizes the compulsory discernibility and the willful detectability [19]. The required recognizability mostly has to do with budgetary purposes and needs definite data about the items with respect to quality angles. Advantageous to obligatory discernibility, willful discernibility alludes to the capacity of each entertainer on the flexibly chain to openly choose what information to accumulate [19]. Defending its name, intentional recognizability isn't necessary for partners to execute. Dependable and complete recognizability is just conceivable when both compulsory and intentional detectability measures exist. Partners engaged with the flexibly chain empower a more point by point and qualitative discernibility framework when they deliberately add data. A primary test for intentional frameworks lies in their intricacy, since each entertainer may have their own principles and techniques for

following and following an item, prompting a wide assortment of procured information [19].

#### 2.4.1 Traceability Tools and Technology

Early following and discernibility frameworks utilized laborers to record the data on the field and afterward physically move them on handbooks or into a PC framework. This strategy involves hazards, for example, defective data recording just as wasteful asset use. In the last ongoing many years, there is a fast advancement of mechanized cycles and items, just as in correspondence advancements, coming about in the purported Internet of Things (IoT) worldview. This fast development of IoT and sensor innovation favors the information gathering methodology by offering quick and dependable strategies. These techniques incorporate innovation for item distinguishing proof, fixing investigation, transportation, stockpiling, just as data catches all through the general framework coordination. Techniques, for example, scanner tags, QR codes, RFID, remote sensor organizations (WSNs) are the most inescapable furthermore, notable among flexible chains.

Because of their qualities, RFID frameworks give a sheltered data and information the executives framework of agri-nourishment for makers, wholesalers, retailers and customers. RFID innovation contributes in agri-food flexibly chain the executives by following and observing the "from homestead to fork" course. When a sanitation issue happens, its source and therefore the arrangement can quickly be found [20,21].

As the food flexibly chain is amazingly intricate and, simultaneously, purchaser needs and mindfulness for new, protected and quality food are persistently developing, detectability frameworks offer numerous points of interest, remembering the reduction for the time expected to review and pull out items hazardous for the general wellbeing, subsequently improving customers' security and certainty. Moreover, recognizability gives the horticulture gracefully chain with straightforwardness and unwavering quality, characteristics of utmost significance considering the multifaceted nature of the food gracefully chain these days.



## 2.4.2 Blockchain and Traceability

Blockchain is additionally an unchanging computerized record, implying that in the event that anybody attempts to alter or degenerate the information of a particular square, hence changing the hash of this square, this will bring about a cryptographic connection interruption, because of the utilization of various hash(es) between the connected squares of the chain. In light of the adjustment in a square in the chain, all the squares after that will not, at this point be legitimate, which implies that it will not, at this point, be associated with the chain.

In Blockchain, changes in blocks are controlled using distributed peer-to-peer (P2P) networks which are the key components of Blockchain technology. In the Blockchain P2P network, a block of chain can be synchronized to ensure transparency and integrity. Every block in Blockchain consists of four major fields: (1) the number of the block, (2) the stored data or transaction, (3) the hash of the previous block and (4) the hash of the current block. The hash is created using SHA256 hashing algorithm to give an identity of each block uniquely.

The early electronic traceability systems were centralized solutions based on databases and data import conducted either in a manual or semiautomatic way. Gandino et al. propose a framework consisting of RFID tags attached on products in a fruit warehouse [22]. The proposed system is a semiautomatic RFID-based traceability platform which was designed in order to test and evaluate the effectiveness and the potential improvement of traceability using automation improvements.

Specifically, the experimental system uses RFID tags for reading products' attributes, RFID readers in order to obtain the data from the tags, personal digital assistant (PDA) devices for the personnel, so they could read the RFID readers, and a central computing system with a central database where the obtained data from the RFID tags on products are stored. This specific case study revealed that the application of RFID technology on agriculture traceability can provide many advantages and improvements, such as shorter time for data management and analysis

Corrado Costa et al. made a survey on RFID and agri-food gracefully chain discernibility in [23], in which the focal points and the potential difficulties with respect to the use of RFID innovation in the food flexibly chain are elaborately introduced. Moreover, a calculated thought of a cloud-based farming discernibility framework is planned as a future work proposition. From that point forward and keeping in mind that the blockchain innovation has been increasingly more ground in information science, the main thoughts and proposition for cloud detectability frameworks utilizing DLTs began to be detailed.

Feng Tian in a research work proposes a progressive thought regarding a framework dependent on RFID and blockchain innovation for Chinese agri-food markets with the point of improving their sanitation and quality, just as diminishing misfortunes during strategic cycles [24]. Tian's work is one of the most referred to in the writing with respect to blockchain applications in the farming area. As indicated by Tian, RFID and blockchain innovation are utilized to ensure sanitation and quality all through the whole flexible chain. The paper inspects two kinds of farming items: (i) new leafy foods, and (ii) meat, for example, pork, chicken and hamburger. The proposed network uses the highlights of blockchains so that everything partners can approach each exchange and data with respect to a particular item. The fundamental point of Tian is to cover the entire cycle of information assortment and data of the executives, for each exchange between the partners in the farming flexibly chain. The whole framework gives checking, following and following of the nature of agri-food and can be described as a "homestead to fork" arrangement. Tian's answer presents the two points of interest and difficulties (thinking about cultural, money related and specialized perspectives) contrasted with brought together arrangements [22].

Arsyad et al. [25] propose a structure that utilizes a two-way factor confirmation blockchain arrangement and what's more, watermarks pictures and records utilizing the discrete wavelet change technique. Hayati et al. [26] present the FoodTrail stage, which utilizes a four-layer design related to shrewd agreements as an approach to direct exchanges through the entire graceful chain. In the exact year, the World Wildlife Asset (WWF) made an undertaking called "Snare to-plate" zeroed in on the discernibility of

fish in New Zealand all through the entire graceful chain. WWF's undertaking embraces RFID advancements for fish labeling and an Ethereum-based blockchain [27].

In the review of the above articles, it has been found that seed quality traceability is still an emerging issue and still at infancy in terms of adoption of technology based solutions using Blockchain and IoT. The proposed research work will be in the direction of seed quality traceability using Blockchain and using a framework driven through the production process.

### <sup>1</sup> 2.4.3 Ethereum and Smart Contracts for Consensus

Etherium, a Blockchain project platform created in the year 2013 by Vitalik Buterin, is a decentralized platform to facilitate Blockchain based business transactions using smart contracts. The "decentralized platform" part implies <sup>5</sup> that anybody can set up and run an Ethereum hub, a similar way anybody can run a Bitcoin hub.

Any individual who needs to run a "brilliant agreement" on the hubs needs to pay the administrators of those hubs in Ether, which is a cryptographic money token attached to Ethereum. Hence, individuals who run Ether hubs give registering power and are paid in Ether, along these lines to how individuals who run Bitcoin hubs give hashing power and are paid in Bitcoin. <sup>1</sup> As it is defined, smart contracts inherit some important attributes such as immutable and distributed because of the storage inside the blockchain. Due to immutability which ensures that no one can tamper with the code of the contract, while being distributed and secures the validation of smart contracts output from everyone on the network. As of now, smart contracts have been used in many types of blockchain applications such as in supply chains and in the health sector.

<sup>6</sup> In a broad sense, smart contracts are computer programs that can automatically execute the terms of contract defined within the scope of the solution using Blockchain. When a predefined <sup>6</sup> condition in a smart contract among contributing entities is met then the parties involved in a contractual agreement can automatically make payments as per the pre-mentioned conditions in contract in a transparent manner.



#### 2.4.4 Private and Public Blockchain

Public blockchain networks are portrayed as permissionless, where anybody can join, perused or potentially compose information, make keen agreements or even run a hub inside them, guaranteeing 100% straightforwardness just as a significant level of secrecy. Public organizations are suggested for substances engaged with crypto-financial matters. Interestingly to public blockchain networks, private organizations confine either member or validator access as an exemplary shut biological system where all companions are all around characterized and just pre-approved substances can run hubs. Following a business-to-business approach, numerous organizations utilize private blockchain networks to profit by this innovation without relinquishing their self-rule. Private blockchains, in differentiation to public ones, commonly utilize a sort of agreement other than PoW (Proof of Work), and might target keeping certain data private from the general population. In outline, public blockchain networks appreciate opportunity in decentralization, though private blockchain networks appreciate opportunity in configurational adaptability [21].

Half and half methodologies additionally exist—these are called permissioned blockchain frameworks. Various flavors of what's more, designs of permissioned blockchain frameworks exist, however commonly the agreement cycle is constrained by a pre-predefined rundown of members, and clients can't take an interest without consent. Admittance to the full data of exchanges on the blockchain may be limited, contingent upon the client job.

Table 1: Use of different blockchain type and implementation

| Public / Private Blockchain | Implementation Platform                         |
|-----------------------------|---|
| Public                      | Ethereum<br>Hyperledger Sawtooth<br>Hyperledger |
| Private                     | Ethereum<br>Hyperledger<br>Mixed                |

The Table 1 shows the different platforms which could be utilized in traceability applications.

## 2.5 Blockchain Architecture for Agriculture

Different researchers worked and are still working in the area of implementing Blockchain for Agriculture and a huge pool of resources are in the experimental stage for bringing Blockchain based solutions for quality food production. One such model is shown below as worked out by researchers Kaijun et.al. [28].

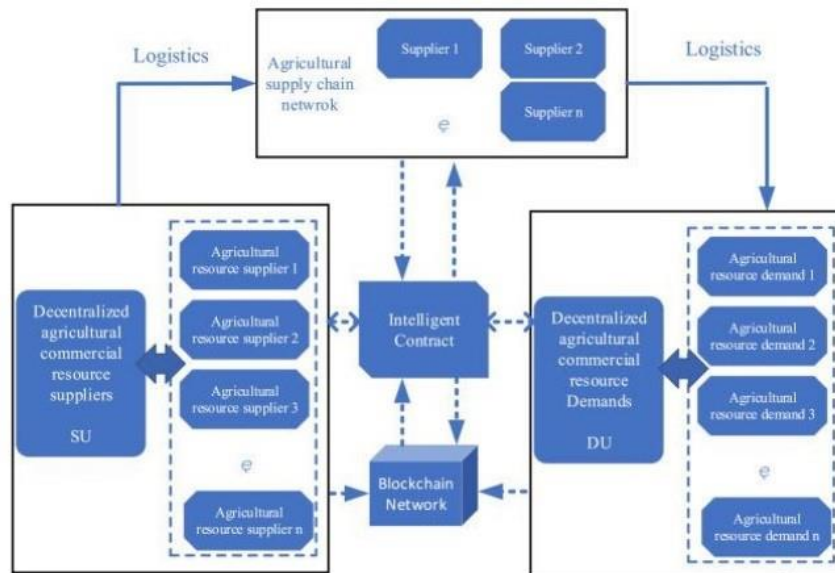


Figure 2.5.1: Blockchain Framework in Agriculture Supply Chain [28]

As seen from a proposed research work in Figure 2.5.1, within the agriculture supply chain network, there are many suppliers and suppliers are associated with logistics. The logistic unit is composed of decentralized agriculture commercial resource suppliers having connected with smart contracts which are within the blockchain network at the heart of the framework. Both the suppliers and agriculture resource suppliers are interconnected through the smart contract with the blockchain network.

## CHAPTER 3

### PROPOSED FRAMEWORK

#### 3.0 Introduction

The business process model of seed production process plays a vital role in the formation of an approach to apply Blockchain for quality control and management of seed. A typical production process is shown in the following Figure 3.0.1.

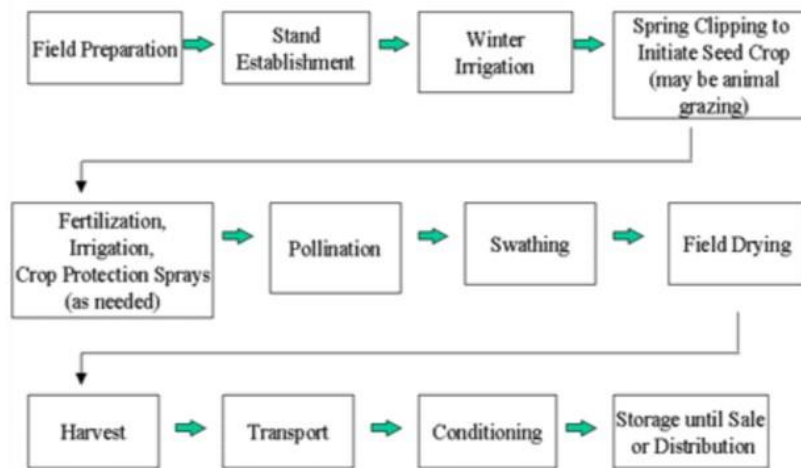


Figure 3.0.1: Typical Seed Production Process

As seen in Figure 3.0.1, the seed production begins with field preparation with necessary fertilizer and irrigation process. Once the stand is ready, and after the winter or seasonal irrigation, followed by fertilization, the pollination begins. Pollination goal is to create offspring for the next generation. One of the ways that plants can produce offspring is by making seeds. After [REDACTED], swathing takes place which processes the crops for the preparation of seeds. Once drying in the field, it gets ready for the harvest and transportation to storage for conditioning and thereafter the distribution to farmers in the field.

In the formation of a framework based on Blockchain, necessary transformation of the business process shown in Figure 3.0.1 is necessary to ensure the traceability of seed for the quality production.

### 3.1 Proposed Framework for Seed Quality Tracing

In the formation of the proposed framework for seed quality tracing using Blockchain, the following considerations and constraints have been made based on the typical seed production process shown in the Figure 3.0.1:

- a. Pre-production Phase: consisting of field production, stand establishment, fertilizer, irrigation and protection spray
- b. Production Phase: consisting of stages covering pollination, swathing, field drying and harvest
- c. Post-Production Phase: consisting of transport, conditioning and distribution of seeds

The different nodes of the proposed framework for seed quality tracing based on Blockchain is shown in the following Figure 3.1.1.

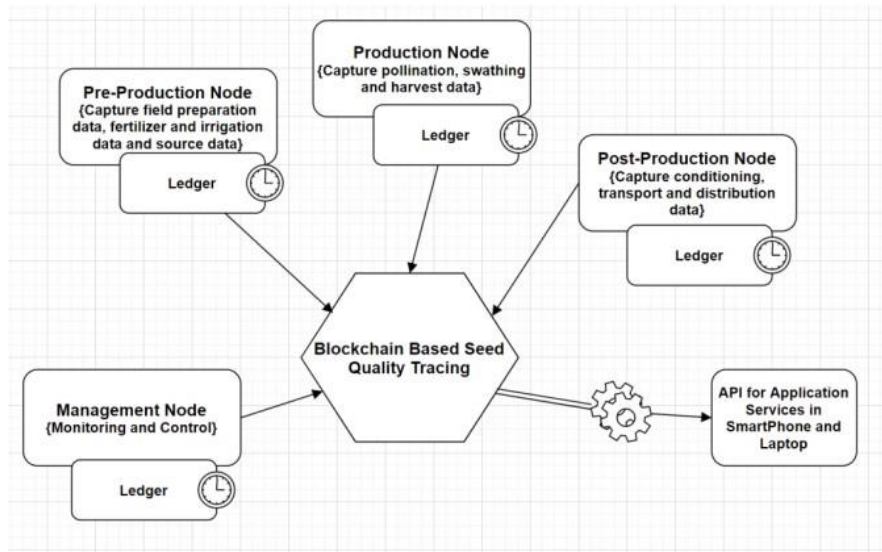


Figure 3.1.1: Nodes in Proposed Blockchain based seed quality tracing



Based on the design constraints, as shown in the Figure 3.1.1 the proposed framework for seed quality tracing based on Blockchain will consist of three categories of nodes: (1) Pre-production nodes: responsible for collecting data related to pre-production phase of the seed production which includes field preparation, fertilizer and irrigation with crop protection data; (2) Production nodes: responsible for collecting data related to pollination, swathing and harvest with specific filtering of seeds; and (3) Post-production nodes: responsible for collecting data related to storage, conditioning and distribution till the field levels. Every node carries its own ledger to reflect specific seed production identity and ensure transparency among the parties. The management node governs the Blockchain data sharing and distribution management. The core Blockchain network will be enabled with Application Programmers Interface (API) to support application development both for the smartphone and laptop and interacting with Internet gateway. The proposed system architecture is shown in the following <sup>15</sup> Figure 3.1.2.

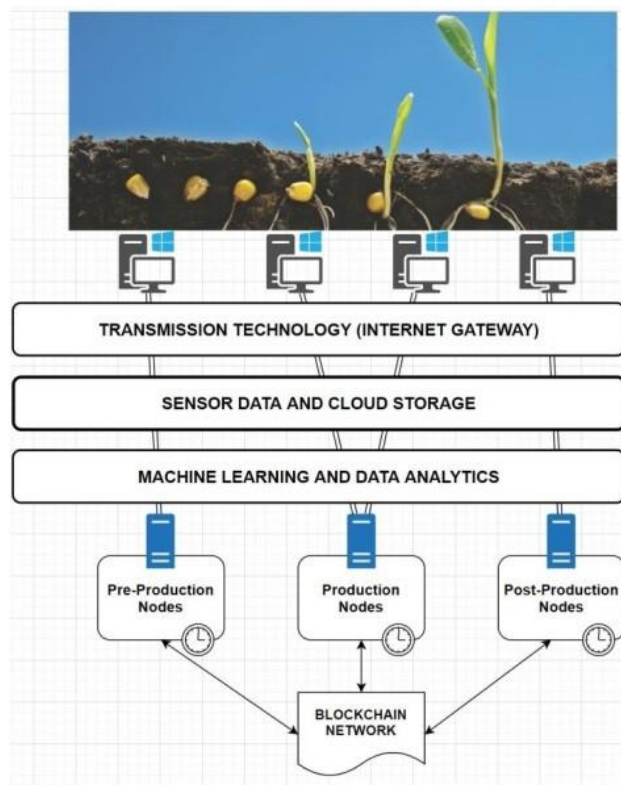


Figure 3.1.2:Proposed Blockchain based seed quality tracing system architecture



14 As shown in Figure 3.1.2, the proposed system architecture consists of nodes responsible for pre-production, production and post-production stages in association with the Blockchain network. The top most layer of the proposed system architecture is connected to the Internet gateway to enable API interactions with the digital services through smartphone and web application. The different sensors used in the tracing of seed quality that generate data at the sensor data and cloud storage layer. These data will be utilized for necessary data analytics using machine learning techniques.

### 3.2 Conceptual Interaction Model

The conceptual interaction model for the proposed seed quality tracing architecture is shown in the Figure 3.2.2.

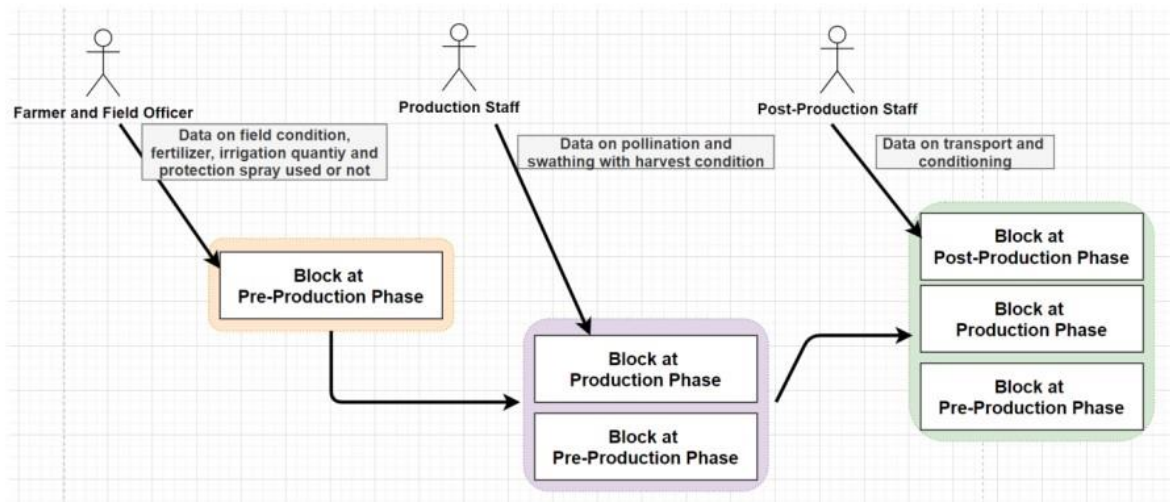


Figure 3.2.2: Conceptual Interaction model of the Proposed Blockchain based seed quality tracing system

As seen from the interaction model in the Blockchain network, starting from Farmer and field officer upon capturing data on field condition, fertilizer used and irrigation, the initial block is created at the pre-production node and this is broadcasted in the seed blockchain network. Soon this information is broadcasted in the Blockchain network,

different stakeholders including production and post-production are notified. The next block is added by the Production staff and it captures data on pollination and swathing. This enables detailed information on seed production quality. After this second stage, the next block is added in the Blockchain network by Post-Production staff and this block captures data on transportation and conditioning. At any point in time, the stakeholders in the network are aware of the seed production quality and stages.

### **3.3 Framework Components**

The proposed framework for seed quality tracing based on Blockchain as elaborated in the sections 3.1 and 3.2 demands well defined components for ensuring growth and continuity. The different components of the proposed framework are:

- a. *Pre-Production Component*: Nodes and sensors dedicated to Pre-Production phase in order to capture data related to irrigation, fertilizer, field conditioning and area. Besides, usage of insecticide and other protection control is also recorded
- b. *Production Component*: Nodes and sensors dedicated to production phases will be responsible to gather data related to pollination and swathing along with other associated processes as required for quality tracing.
- c. *Post-Production Component*: Nodes and sensors dedicated to the post-production phase will be responsible for collecting data related to conditioning and transportation.
- d. *API Interaction Component*: Nodes responsible to provide data analytics and quality tracing services based on the Blockchain network with the help of application programming interface (API) to be used in mobile apps and web applications for the public usage.

### 3.4 Implementation Challenges

The proposed framework for seed quality tracing using Blockchain implementation has some rigorous challenges as the data primarily requires engagement of farmers and is vastly dependent on the field level. The following key challenges lie in the successful deployment of the proposed framework for seed quality tracing using Blockchain:

- (a) *Sensor based data collection for irrigation and fertilizer*: this challenge lies with the appropriate selection and/or development of sensor based data acquisition module to facilitate automatic or semi-automatic data collection in the pre-production, production and post-production phases
- (b) *Deployment of intelligent nodes at the field level*: this challenge lies with the appropriate design of the Blockchain network based on field condition and using sustainable technology
- (c) *Education of farmers for quality seed tracing application usage*: this challenge lies with the education of farmers in using mobile apps or web applications to identify seed quality parameters before sowing in the field
- (d) *Adaptation to Technology change*: this challenge lies with the adaptation of technology change in order to ensure scalability and growth over the time

## CHAPTER 4

### SIMULATION OF PROPOSED FRAMEWORK

#### 4.0 Introduction

There are top platforms designed for implementation of Blockchain based solutions. Top giants like IBM and Amazon contributed a lot in making this happen. As one of the younger blockchain environments, IOTA took to the blockchain landscape with a mission to fundamentally change the way that people access distributed ledger technology. The target is to ensure a more secure environment for exchanging values and data without fees. Though IOTA doesn't actually use any chains or blocks, and is instead powered by its own unique technology. Another platform called OpenChain is a public blockchain platform developed by Coinprism. This powerful environment helps companies create information systems for experimentation.

Another very known implemen Hyperledger Sawtooth is a blockchain offering made available from the Linux foundation. The Sawtooth is a modular enterprise-grade platform where experts can create, deploy, and execute distributed ledgers. Another popular platform called Ethereum is also a blockchain platform. Since 2013, Ethereum has offered blockchain developers an open-source distributed computing platform where application blockchain can be deployed. With the use of Ethereum, one can write codes using the Ethereum Virtual Machine run-time environment. IBM also has offered an exciting blockchain platform called HyperLedger, which offers more transparent environments for company operations. Using IBM Blockchain Hyperledger, companies can better redefine their business relationships through trust, transparency, and newfound collaboration.

In this research work, ChainRider, a platform designed to test blockchain solutions as part of the Proof of Concept (PoC) is used for prototype experiments. In the context of Blockchain, ChainRider offers an unique ecosystem of tools and services built around public and private blockchain which help to develop, prototype and build proprietary

applications on the blockchain in a fast and simple manner. This PoC is to ensure the working of the proposed solution of seed quality tracing using blockchain.

#### 4.1 Simulation of Proposed Framework

The chainrider.io is an open platform and the following process and user interfaces displays the formulation of the prototype for the proposed solution.

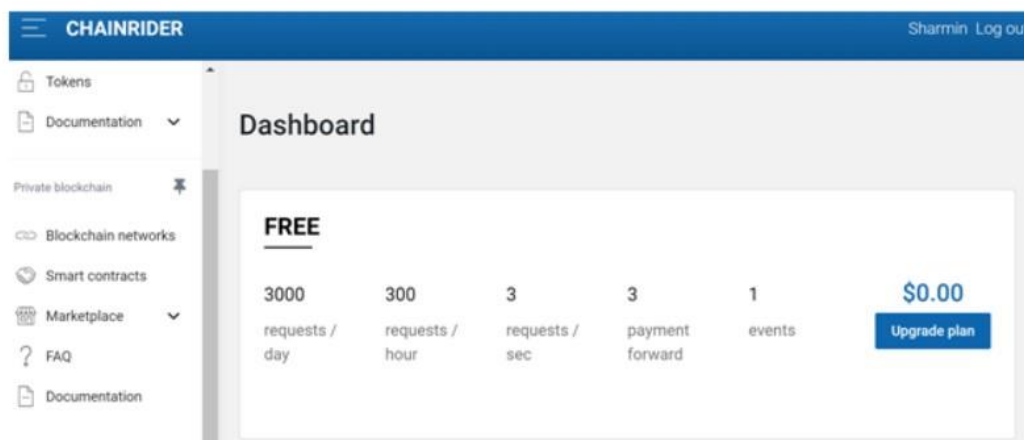


Figure 4.1.1: Web front end of Chainrider Blockchain Platform

As seen from Figure 4.1.1, the Chainrider framework provides blockchain prototype development on the top of Hyperledger fabric. The web front end show the necessary tools to create a Blockchain network, smart contracts and also export the network for use in the production platform to serve the marketplace.

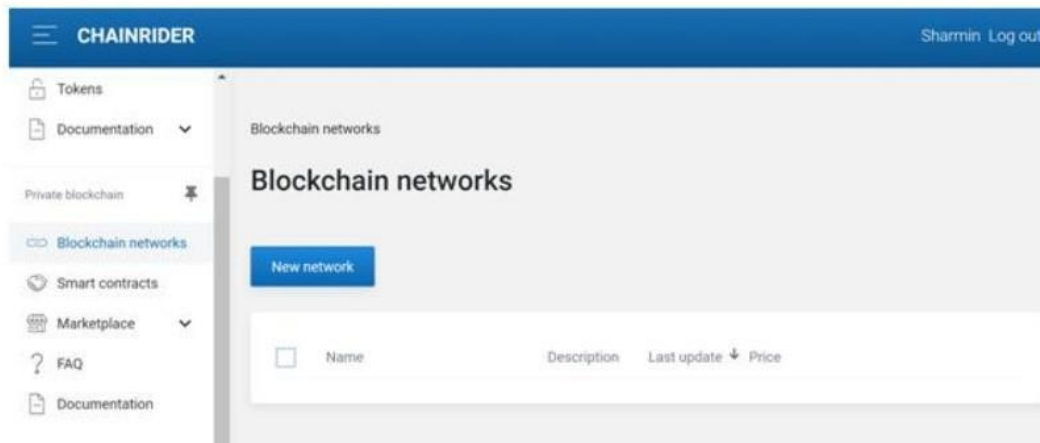


Figure 4.1.2: Web front end for Blockchain network in Chainrider Blockchain Platform

The new blockchain network creation in Chainrider is shown in Figure 4.1.2. The new network needs detailed description of organization, services, peers and machine interactions in peers for the network to function. The seed quality tracing blockchain network is created and shown in Figure 4.1.3.

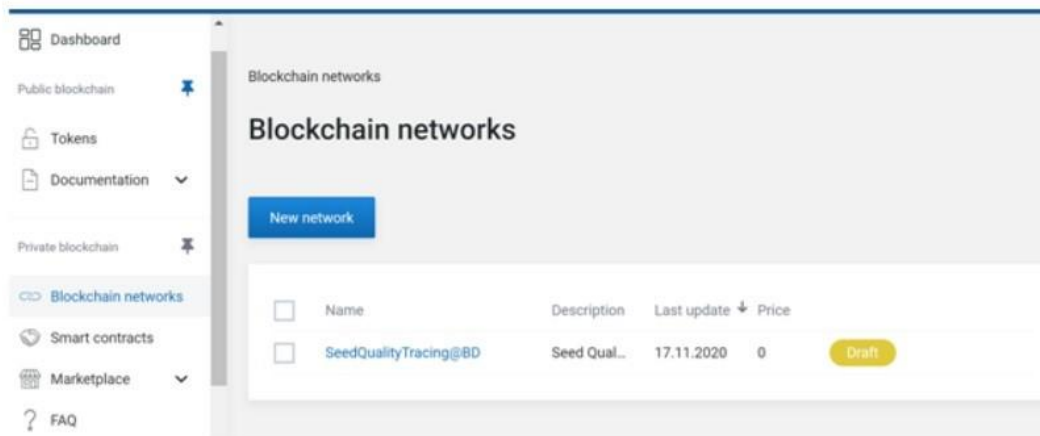


Figure 4.1.3: Web front end for Blockchain network after creation of SeedQualityTracing in Chainrider Blockchain Platform

The seed-to-serve-diu block chain network with its parameters is shown in the Figure 4.1.4 below.



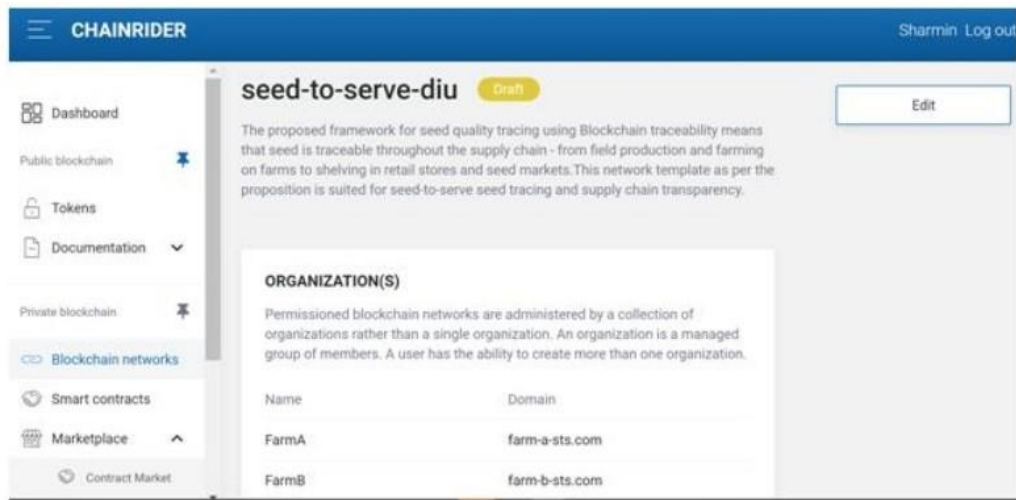


Figure 4.1.4: Web front end for Blockchain network seed-to-serve-diu in Chainrider Blockchain Platform

The different channels for pre-production, production and post-production are created for the transaction services in blockchain network and [REDACTED].5.

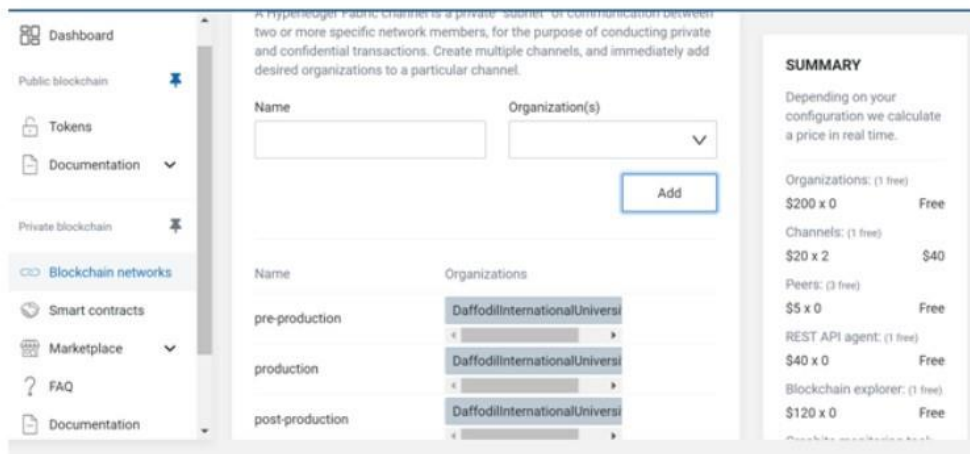


Figure 4.1.5: Web front end for different channels in Blockchain network for seed tracing in Chainrider Blockchain Platform

In every channel based on seed production business process including pre-production, production and post-production, peers are created as a representation of node in the blockchain network. The pre-production channels are shown in Figure 4.1.6.

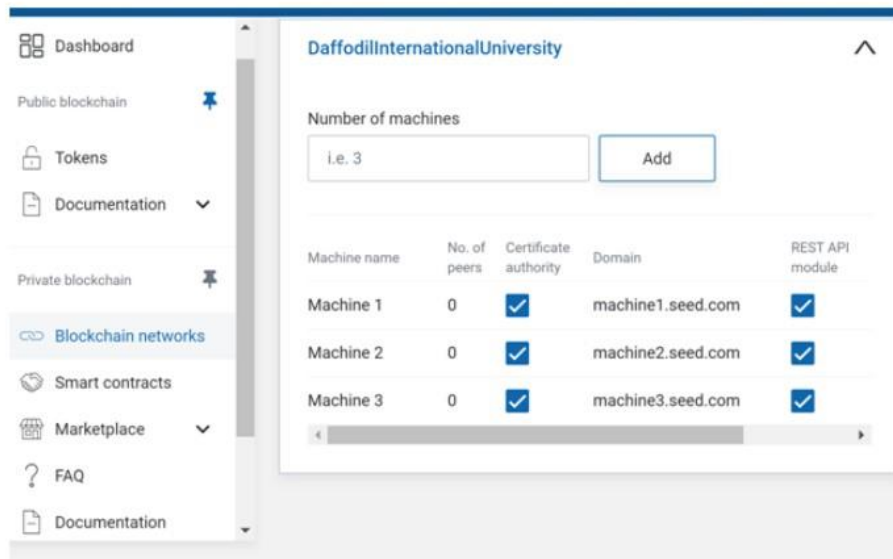


Figure 4.1.6: Web front end for peers in pre-production channel in Blockchain network for seed tracing in Chainrider Blockchain Platform

Once the blockchain network is created in Chainrider, the entire files are exported to production server for real-life deployment. The summary snapshots are shown in Figure 4.1.7.

## SeedQualityTrace@BD

Draft

The proposed framework for seed quality tracing using Blockchain traceability means that seed is traceable throughout the supply chain - from field production and farming on farms to shelving in retail stores and seed markets. This network template as per the proposition is suited for seed-to-serve seed tracing and supply chain transparency.



## ORGANIZATION(S)

Permissioned blockchain networks are administered by a collection of organizations rather than a single organization. An organization is a managed group of members. A user has the ability to create more than one organization.

| Name           | Domain                  |
|----------------|-------------------------|
| PreProduction  | preprod.seed.com        |
| Production     | production.seed.com     |
| PostProduction | postproduction.seed.com |

## CHANNELS

A Hyperledger Fabric channel is a private "subnet" of communication between two or more specific network members, for the purpose of conducting private and confidential transactions. Create multiple channels, and immediately add desired organizations to a particular channel.

| Name           | Organization(s) |
|----------------|-----------------|
| fertilizer     | PreProduction   |
| irrigation     | PreProduction   |
| harvesting     | PreProduction   |
| pollination    | Production      |
| swathing       | Production      |
| conditioning   | PostProduction  |
| transportation | PostProduction  |

Figure 4.1.7: Web front end for seed tracing in Chainrider Blockchain Platform

## 4.2 Operational Aspects

The operational aspects of the defined blockchain network from Chainrider entirely depends on the hyperledger framework and peer-to-peer network nodes. Once the network is created in Chainrider, the downloaded network can be deployed in the production platform. Each of the channel with its associated peer in the downloaded source will be configured accordingly. The expected target platform will be Unix 64bit architecture with 1GB RAM. As part of the software components nodejs, docker, docker

compose, gcc and other compilers will be required. During the deployment of the blockchain network, the orderer service will be deployed first in association with the domain and port. After the orderer service has been deployed successfully, the machine or peer will be deployed in connection to the domain. ChainRider adds machine name as a subdomain meaning the entire domain name for a machine will be machine{N}.{domain\_you\_have\_specified\_for\_that\_machine}. The final step in the deployment is setting up REST (REpresentational State Transfer) API for the application services.

### 4.3 Simulation Results

The simulation of the proposed framework for seed quality tracing using Blockchain is created using Chainrider based on hyperledger fabric and different actors based on the business process model of seed production is created in the blockchain network. The proposed framework for pre-production, production and post-production phases of seed is formulated as an organization unit , each organization unit has channels based on the action unit of pre-production, production and post-production phases has peers associated based on domain. The prototype blockchain network is simulated in Chainrider.

## CHAPTER 5

# DISCUSSION AND CONCLUSION

### 5.1 Discussion

In this **research** work, we tried to look at through understanding of blockchain with detail on how to create a blockchain network. The different architecture of blockchain networks along with the application of blockchain in developing business solutions is also addressed. The proposed topic of seed quality tracing using blockchain is an utmost importance to national productivity and food security. The investigations were carried out to develop insights on using blockchain for seed quality tracing and respective challenges. Alongside the seed quality tracing, framework understanding based on seed production process is investigated for necessary transformations in creating a framework for blockchain network.

### 5.2 Conclusion

In the formation of the proposed framework for seed quality tracing using Blockchain, through investigation is carried out to develop a clear understanding of Blockchain, blockchain architecture and application design based on blockchain. Different approaches are studied to develop insights on seed quality tracing based on the business process model of seed production and management. The conceptual framework for seed quality tracing is developed based on seed production process and requirements for seed quality issues. The conceptual framework including the system architecture is proposed for the seed quality tracing. The proof of concept (PoC) is carried out in Chainrider through creation of a blockchain network.