Project Report On

Supply Chain Traceability for Organic Jaggery

Submitted By

Ayush Bansal 17u112
Lokesh Budhlani 17u273
Aadesh Ingle 17u354
Siddesh Vyavahare 17u373
Ashish Gole 17u688

Under the Guidance of

Prof Dr. Priya Shelke

In Partial fulfilment of
Bachelor of Technology
[B. Tech Information Technology]
[2020-2021]
At

Department of Information Technology
Vishwakarma Institute of Information Technology, Pune 411048

Affiliated To

Savitribai Phule Pune University, Pune

SUPPLY CHAIN TRACEABILITY FOR ORGANIC JAGGERY

Bansilal Ramnath Agarwal Charitable Trust's

Vishwakarma Institute of Information Technology, Pune 411048

Certificate

This is to certify that the work entitled **"Supply Chain Traceability for Organic Jaggery"** is a Bonafide work carried out by Mr. Ayush Bansal, Mr. Lokesh Budhlani, Mr. Aadesh Ingle, Mr. Siddesh Vyavahare, Mr. Ashish Gole in partial fulfilment of the award of Bachelor of Technology in Information Technology, Savitribai Phule Pune University, Pune, during the year 2020-2021. The project report has been approved as it satisfies the academic requirements in respect of the project work prescribed for the Bachelor of Technology Degree.

Prof. Dr. Priya Shelke
Project Guide

Prof. Pravin Futane
Head, IT Department

Dr. Vivek Deshpande
Principal, VIIT, Pune

Date:

Examiners: 1. . . . . .

Place: Pune

2. . . . . .

CIN U72900MH2019PTC320411

EMERTECH INNOVATIONS

Emertech Innovations Private Limited
Room No 1, TCS Shed, SINE, IIT Bombay
Powai, Mumbai – 400076, Maharashtra, India
Email: info@emertech.io
Director Contacts: +91 9890604028 / +91 9561707654

Project Sponsorship Allocation letter

To,

The Head-IT, VIIT

We confirm that the project "Supply Chain Traceability for Organic Jaggery" is allocated to the following team (Ayush Bansal 17u112, Lokesh Budhlani 17u273, Aadesh Ingle 17u354, Siddesh Vyavahare 17u373, Ashish Gole 17u688). We hope that your team will sincerely complete it in the duration from July 2020 to December 2020 under the guidance of the Mr. Gaurav Somwanshi who has been allocated to you from the company.

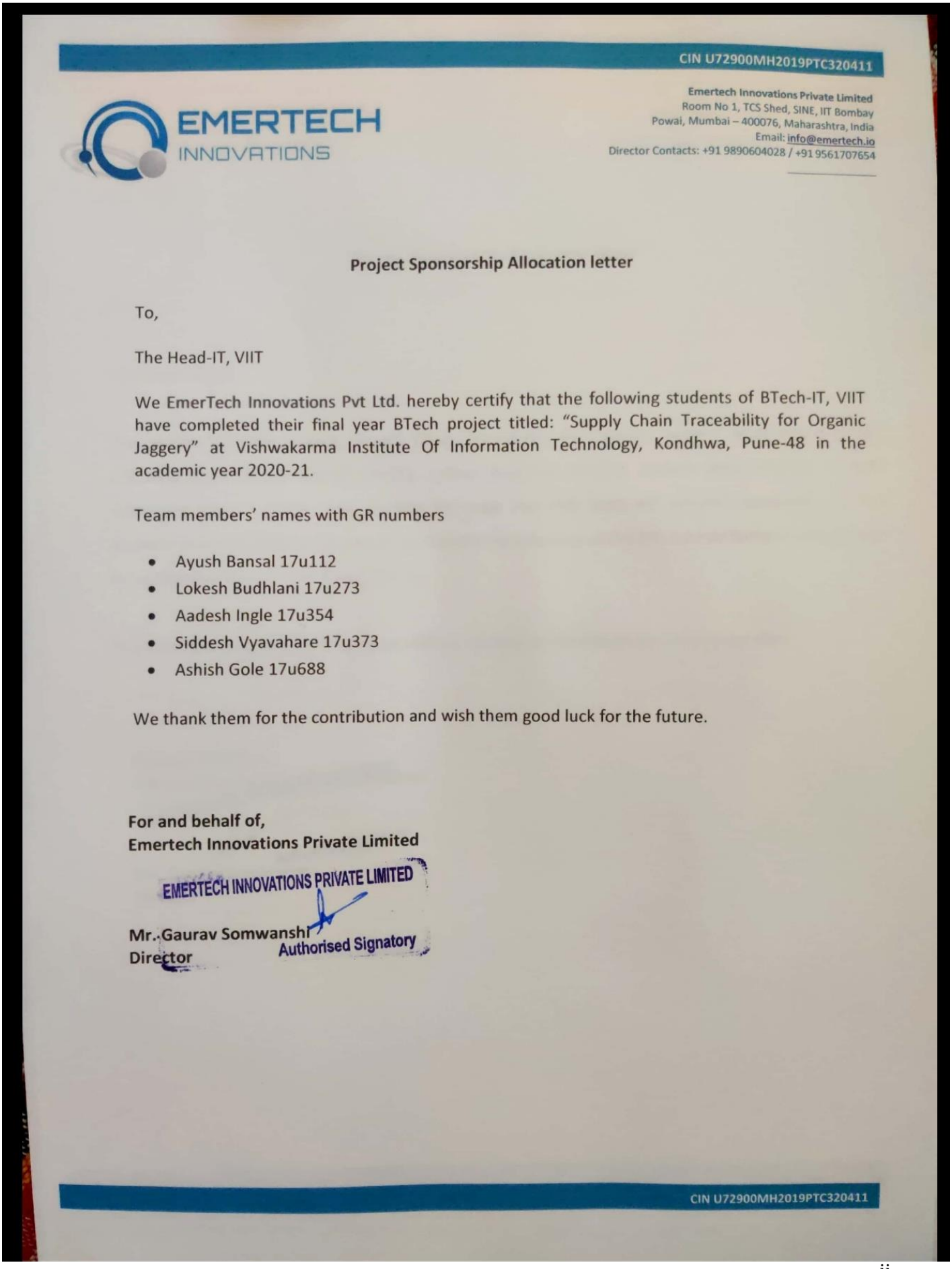
Thank you for your interest in working with us. Looking forward to an amazing association.

For and behalf of,
Emertech Innovations Private Limited

EMERTECH INNOVATIONS PRIVATE LIMITED
Authorised Signatory

Mr. Gaurav Somwanshi
Director

CIN U72900MH2019PTC320411



CIN U72900MH2019PTC320411

EMERTECH INNOVATIONS

Emertech Innovations Private Limited
Room No 1, TCS Shed, SINE, IIT Bombay
Powai, Mumbai – 400076, Maharashtra, India
Email: info@emertech.io
Director Contacts: +91 9890604028 / +91 9561707654

Project Sponsorship Allocation letter

To,

The Head-IT, VIIT

We EmerTech Innovations Pvt Ltd. hereby certify that the following students of BTech-IT, VIIT have completed their final year BTech project titled: "Supply Chain Traceability for Organic Jaggery" at Vishwakarma Institute Of Information Technology, Kondhwa, Pune-48 in the academic year 2020-21.

Team members' names with GR numbers

- Ayush Bansal 17u112
- Lokesh Budhlani 17u273
- Aadesh Ingle 17u354
- Siddesh Vyavahare 17u373
- Ashish Gole 17u688

We thank them for the contribution and wish them good luck for the future.

For and behalf of,
Emertech Innovations Private Limited

EMERTECH INNOVATIONS PRIVATE LIMITED

Mr. Gaurav Somwanshi
Director

Authorised Signatory

CIN U72900MH2019PTC320411

I

Acknowledgement

We take this opportunity to thank Head of the Department Prof. Pravin Futane and our project guide Prof. Dr. Priya Shelke for their valuable guidance and providing all the necessary facilities, which were indispensable in the completion of this project report. We are also thankful to all the staff members of the Department of Information Technology, VIIT, Pune for their valuable time, support, comments, suggestions and persuasion. We would also like to thank the institute for providing the library facility even in these hard times.

Ayush Bansal 17u112
Lokesh Budhlani 17u273
Aadesh Ingle 17u354
Siddesh Vyavahare 17u373
Ashish Gole 17u688

II
Abstract

Food holds a significant role in human beings' lives and human societies in general across the planet. The large number and heterogeneity of the stakeholders involved from different sectors, such as producers, distributors, retailers, customers, and quality checkers, render agricultural supply chain management one of the most complex and challenging tasks. Nowadays, the customers are unaware of the events happening to the supply chain items, which creates a lack of trust in their minds. So, the solution to this problem can be implemented efficiently using Blockchain technology. This project is intended to explore transparency in the supply chain of food products by using Blockchain technology. It allows for decentralized data storage and provides immutability. The decentralized data storage makes it impossible for an unauthorized actor to tamper with the data. Our findings indicate that blockchain is a promising technology towards a transparent supply chain of food, with many ongoing initiatives in various food products and food-related issues. However, many barriers and challenges still exist, which hinder its wider popularity among farmers and systems. These challenges involve technical aspects, education, policies, and regulatory frameworks. This project discusses relevant methodologies to replace the ongoing methods employed by the industry to trace products in the supply chain, thus leading to a massive decrease in cost and efforts for the stakeholders and making products cheaper for the customers. The blockchain could also be deployed on cloud services to increase availability and reliability. The methodologies presented in this project can be used by any food manufacturing industry that wants to track the products better and explore transparency in the supply chain.

III

Contents

IV

List of Figures

V

List of Tables

Chapter 1
Introduction

1.1 Motivation

Food supply chains have a vast complexity, which is often the cause of a lack of transparency and traceability. On top of that, a significant issue directly affecting public health is food safety. During the past twenty years, various food epidemic incidents have been reported [1], like the foot-and-mouth Disease in Europe in 2001, the Escherichia coli outbreak in spinach in 2006 in the USA, the Sanlu milk scandal in China in 2008, the E. coliO104:H4 outbreak in Germany in 2011, the South African listeriosis outbreak in 2017–2018, etc. Governments and health organizations, in an attempt to prevent such dangerous outbreaks, have established relevant directives, laws as well as standards and regulations. For example, in Europe, the traceability of food products is compulsory according to the European Directive 178/2002 since 1 January 2005, together in compliance with the HACCP (Hazard Analysis and Critical Control Points) principles. Likewise, regulations all over the world have been established, aiming to diminish food epidemic incidents. Nowadays, consumers' concerns regarding food provenance and quality are profound, resulting in the tendency to spend more money on food products whose origin is certified. Despite the developed technologies that are already in use, in many cases, the vast majority of the traceability systems are centralized, asymmetric, and outdated in terms of data sharing and interoperability. Existing systems lack transparency and consumers' trust due to the unavailability of a fast and trustworthy way to retrieve information on the product's provenance. Considering all the above, together with the rapid technological development adopted in value chain areas, we observe a significant increase in emerging innovations that lead the way for new digital traceability systems by taking advantage of information and communication technology (ICT), Radio-Frequency Identification (RFID) sensors, Internet of Things (IoT), blockchains and more. In this context, distributed ledger technologies (DLT) such as blockchain offer a solution to many existing problems but simultaneously pose new challenges as well.

1.2 Need for Supply Chain Traceability using Blockchain

Since 2014 it has increasingly been realized that blockchain can be used for much more than cryptocurrency and financial transactions so that several new applications are being explored(Tayeb and Lago 2018): handling and storing administrative records, digital authentication and signature systems, verifying and tracking ownership of intellectual property rights and patent systems, enabling smart contracts, tracking patient health records, greater transparency in charities, frictionless real-estate transfers, electronic voting, distribution of locally produced goods and, in general, for tracking products as they pass through a supply chain from the manufacturer and distributor to the final buyer. Such changes are already revolutionizing many aspects of business, government, and society in general, but they might also pose new challenges and threats that need to be anticipated. Many of these new applications combine blockchains and distributed ledger technologies (DLTs) with smart contracts and decentralized applications, making third party tampering or censorship virtually impossible (Buterin 2015).

The customers are unaware of the events happening to the items in the supply chain thus creating a lack of trust in the minds of the customers. The customers are also unsure if the product is truly organic. The decentralized data storage makes it impossible for an actor to change an item's details without having proper authorization.

1.3 Brief Introduction to Blockchain

Nakamoto [2][3] proposed a decentralized digital currency, Bitcoin, supported by a decentralized payment system. Decentralization refers to an operating mechanism that allows peer-to-peer (P2P) exchange or transactions with-out centralized authorities. This disruptive innovation eliminates the heavy reliance on powerful third parties. Blockchain is the technology underpinning the Bitcoin cryptocurrency, which is a consecutive growing list of blocks, wherein each block records encrypted transactional data and may have further potential for other decentralization purposes [4]. The Operating nodes in this kind of collaborative network have a duplicate record of transactional information, known as a ‘‘ledger.’’ Inherently shared by participating nodes, Distributed Ledger Technology provides the opportunities for a trust less operating environment without traditional trusted authorities such as banks and

clearinghouses. P2P exchange facilitates trust-building among participating nodes and the shared ledger is maintained by nodes in the network.

Computer nodes comply with an encrypted protocol to verify updated data in the shared ledger. This kind of distributed ledger system harvests the benefits of decentralized governance which may solve the issue of information expo-sure and accountability [5]. This inherent attribute favours the interactions between counterparties in the context of business operations [6]. Critical information could be maintained without checking the consistency of individual data and every single node possesses a duplicate of transactional data, thereby enhancing the transparency and visibility of business activities.

In a supply chain context, this kind of system and operational scheme may provide a better foundation of trust as well as benefits resulting from the absence of a centralized authority and intermediation [7]. Accordingly, blockchain could further be utilized to record the ownership of assets [8], permissions, and activity logs. This improves the traceability of information, cash, and process flows, and thus provides timely tracking of products and services. The different types of blockchain are public, private, and consortium (or federated) blockchains, each of which could be applied in certain scenarios to gain better advantages and for effectiveness.

1.4 Reason behind using Blockchain

1. Blockchain is tamper-proof so data cannot be deleted, thus provides trusted environment even when untrusted actors are present.
2. Blockchain provides security to the data as data is encrypted.
3. Blockchain maintains a separate ledger on each and every node thus making it fault-tolerant.
4. Blockchain Technology uses Consensus Mechanisms so data cannot be added without being approved by block miners.

1.5 Applications on Blockchain

Use of Blockchain is not limited to Supply Chain Management and can be used in following applications:

1. Asset Management: Trade Processing and Settlement
2. Insurance: Claims processing
3. Payments: Cross-Border Payments
4. Passports
5. Birth, wedding, and death certificates
6. Personal Identification

Chapter 2
Literature Survey

2.1 Supply Chain Traceability using Blockchain

The food chain is highly distributed and comprises numerous actors, such as farmers, transportation companies, manufacturers, dispatchers, distributors, wholesalers, retailers, and customers. [9]

The main phases of a food supply chain are described below.

1. *Production*: The production phase represents all agricultural activities implemented within the farm. The farmer uses raw and organic material such as seeds, fertilizers, etc., to grow crops.

2. *Processing*: The processing phase concerns transforming a primary product into one or more other secondary products. It can be followed with a packaging phase where each packaged product can be identified uniquely using a QR code or product identification code, which can be used in the further phases to add/ retrieve product-related information.

3. *Quality Checks*: After the product is ready, quality checks are performed either internally or externally. The internal quality assurance team makes sure that the product is packaged according to the given specifications. In contrast, the external quality assurance team can be any food agency such as FSSAI, which checks if the product is quality compliant and also if the product is organic so that the product can be given an organic certification.

4. *Distribution*: Once the product is ready and organic quality is verified, it is released for the distribution phase. It also involves the storage of food products under a specific range of temperature and humidity for preserving the organic quality of the food products.

5. *Retailing*: After the distribution phase, the products are delivered to retailers who perform the organic product's sale. The end-user of the chain will be the customer, who will trace the product and then will decide on purchasing the product.

6. *Consumption*: The customer is the end-user of the food chain. The customer can retrieve the product information and details about product storage using the QR code or the product identification code assigned to the product in the processing phase. The customer can then decide on purchasing the product if he/she finds it to be quality compliant.

Figure 1 Food Supply Chain

2.2 Review of existing System

The research on using blockchain technology in supply chain management for food began in 2016 when the blockchain technology was maturing and becoming more mainstream in other application domains such as in real estate, in exchange for cryptocurrencies, and gaming. There is evidence that applications for supply chain management were being developed using blockchain technology soon after the technology appeared [14]. Blockchain in supply chain management is projected to grow at an annual growth rate of 87% and increase from $45 million in 2018 to $3,314.6 million by 2023 [15].

While the blockchain technology is succeeding and proving its functionality in many cryptocurrencies, various organizations such as IBM and Linux Foundation aim at harnessing its transparency and fault tolerance in order to solve problems in an environment where numerous untrusted actors get involved in the distribution of some resource such as food products in a supply chain [16].Walmart and Kroger were among the first companies to work on blockchain and to include the technology into their supply chains [17], working initially on case studies that focus on Chinese pork and Mexican mangoes[18].

Moreover, in April 2017, Intel demonstrated how Hyperledger Sawtooth (Hyperledger 2018), a platform for creating and managing blockchains, could facilitate traceability at the seafood supply chain. The study used sensory equipment to record information about the fish location and storing conditions. As another example, Louis Dreyfus Co (LDC), one of the world's biggest foodstuffs traders, teamed up with Dutch and French banks for the first agricultural commodity trade (i.e. a cargo of soybeans from the US to China) based on blockchain [19]. According to LDC, by automatically matching data in real-time, avoiding duplication and manual checks, document processing was reduced to a fifth of the time.

Caro et al. propose an integrated solution of a blockchain platform named AgriBlockIoT in the agriculture supply chain. AgriBlockIoT is a fully distributed system that uses blockchain technology in combination with IoT devices in order to collect and distribute traceability data. The proposed solution was tested with two different blockchain platforms, namely Hyperledger

Sawtooth and Ethereum. Trial results showed that Ethereum performed considerably better compared to Hyperledger Sawtooth, in terms of latency, CPU, and network usage.

In the same year, the World Wildlife Fund (WWF) created a project called “Bait-to-plate” focused on the traceability of tuna in New Zealand throughout the whole supply chain. WWF’s project adopts RFID technologies for fish tagging and an Ethereum-based blockchain. Downstream beer is the first company in the beer sector to use blockchain technology, revealing everything one wants to know about beer, i.e. its ingredients and brewing methods. Every aspect of this craft beer is being recorded and written to the blockchain as a guarantee of transparency and authenticity. Consumers can use their smart-phones to scan the QR code on the front of the bottle and they are then taken to a website where they can find relevant information, from raw ingredients to the bottling.

In January 2018, the World Wildlife Foundation (WWF) announced the Blockchain Supply Chain Traceability Project (WWF 2018), to eliminate illegal tuna fishing by means of blockchain. Through the project, fishermen can register their catch on the blockchain through RFID e-tagging and scanning fish. The traceability of tuna is also the focus of Balfegó[20]

Furthermore, ripe.io has created the Blockchain of Food[21], which constitutes a food quality network that maps the food’s journey from production to our plate. Ripe.io has recently raised $2.4 million in seed funding in a round led by the venture arm of global container logistics company Maersk.

Chapter 3

Project Statement

3.1 Purpose behind the Project

The project titled "**Supply Chain Traceability for Organic Jaggery**" is built from the perspective of both producers and customers of the Supply Chain for Organic Product (Jaggery). It aims to provide traceability in the Supply Chain by displaying the current status of a particular product at any time. This system allows the producer to add new orders on the blockchain and customers to trace the product. This product also enables the other actors to update the status of the product.

This project can be used by any organic manufacturing industry that wants to better track the products and bring transparency in the supply chain while saving costs and manual work.

3.2 Decision of Scope

Various actors involved in the supply chain are Manufacturers, Dispatcher, Distributors, Wholesalers, Retailers, and Customers. The customers are unaware of the events happening to the items in the supply chain thus creating a lack of trust in the minds of the customers. The customers are also unsure if the product is truly organic. This project is intended to bring transparency in the supply chain of Jaggery by using Blockchain Technology (Multichain) which allows for decentralized data storage and provides immutability. The decentralized data storage makes it impossible for an actor to change an item's details without having proper authorization.

This project is expected to replace the ongoing methods employed by the industry to trace products in the supply chain, thus leading to an immense decrease in cost and efforts for the producers and making the products cheaper for the customers. This project will also provide the customers with surety of product being fresh and organic.

3.3 Architecture

The components of the system involve:

1. The backend i.e. business logic will be developed using JavaScript language on the Multichain framework which is based on Blockchain technology.

2. The frontend i.e. user interface will be developed using HTML, CSS, JavaScript, and use of any particular frontend framework like AngularJS, ReactJS.

3. The nodes representing the various actors will be deployed on AWS Cloud Services to ensure high availability and fault-tolerant working of the application.

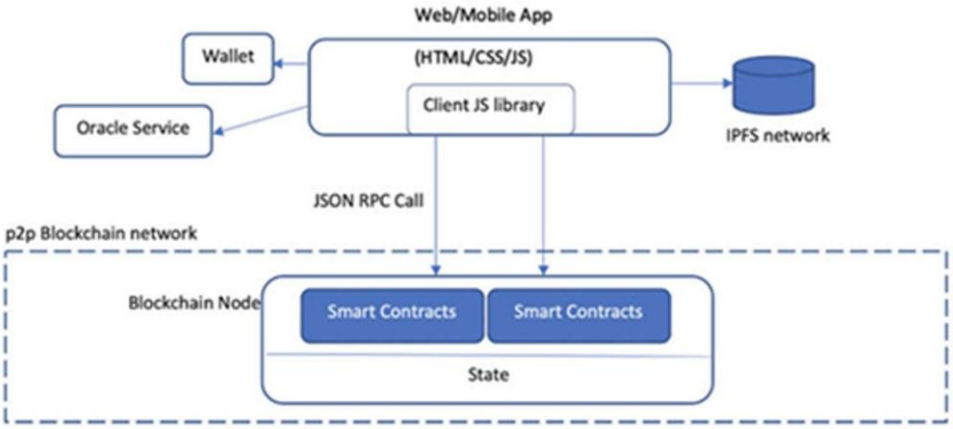


Figure 2 Structure of the Blockchain-based Application in general

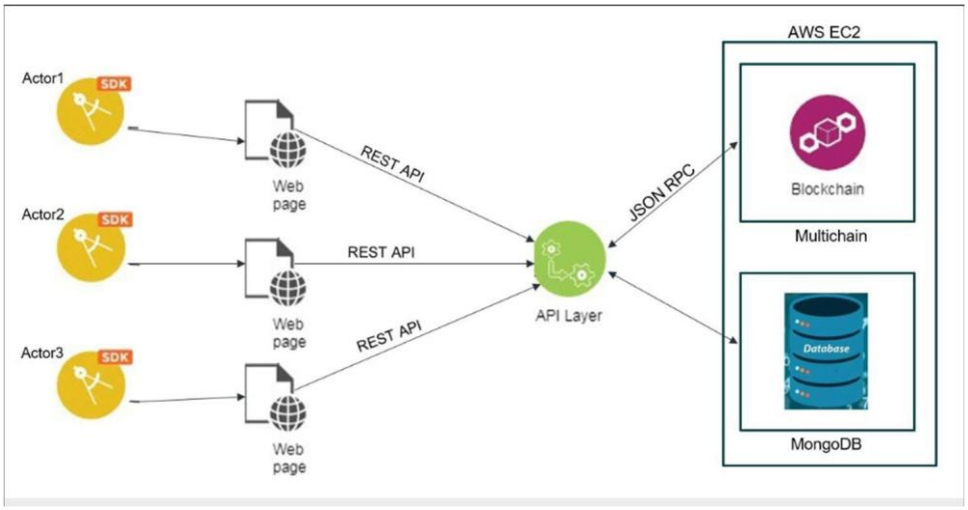


Figure 3 System Architecture

3.4 Working of the System

Actors or systems interact with the blockchain through web pages as shown in above Fig. 2. Web pages further interact with the API Layer in order to record or retrieve transactions on the blockchain. Tokens are implemented for security purposes in the interaction between nodes and blockchain. Business logic is implemented along with the API in the middle layer. A database implementation helps in authenticating users.

Web pages are implemented using HTML, CSS and JavaScript. JavaScript is a dynamic computer programming language. It is a lightweight, interpreted programming language which is designed for creating network-centric applications and is most commonly used as a part of web pages, whose implementations allow client-side script to interact with the user and make dynamic pages. Ajax calls are used at multiple points in order to send and retrieve data from a server asynchronously without interfering with the display and behaviour of the existing page.

API is implemented on NodeJS and expressjs (JavaScript-based platform). REST (Representational State Transfer) API is preferred since it is lightweight, highly scalable and maintainable. Since this web application has to handle more than one pair of request-response to complete, session management is implemented in order to track its current status. Typically, a session is started when a user authenticates their identity using login credentials. API plays an important role in interacting with the multichain server in order to send and retrieve data. Multichain-node library is used for building native JavaScript clients in this web application.

Permissioned blockchain is built on the Multichain platform. Multichain is an extended open-source fork of Bitcoin which can be used to launch custom blockchains, both private and public. It offers a well-selected set of features and enhancements targeted at enterprise and business users [22]. MongoDB is implemented for authenticating users. It includes various actors' details, login credentials and sessions. MongoDB is a cross-platform, document-oriented database that provides, high performance, high availability, and easy scalability.

Blockchain with multichain is deployed on Amazon Web Services (AWS) cloud. JSON-RPC is a stateless, light-weight remote procedure call (RPC) protocol which helps in interaction between API and multichain . Primarily this specification defines several data structures and the rules around their processing. It is transport agnostic in that the concepts can be used within the same process, over sockets, over HTTP, or in many various message passing environments. It uses JSON (RFC 4627) as data format.

A Multichain blockchain can contain any number of streams, where the data published in every stream is stored in full or referenced by a hash inside transactions. Multichain streams enable a blockchain to be used as a general purpose append-only database [22]. It provides a natural abstraction for blockchain use cases which focus on general data retrieval, timestamping and archiving. Each stream is an ordered list of items, with the following characteristics:

- One or more publishers.
- One or more keys.
- Some data in JSON, text or binary format.
- Information about the item's transaction and block.

One stream called product-data is created to store data. Data can be queried from streams using JSON-RPC calls. Three major functionalities implemented using streams such as add product, update product status and trace product. In add product the data is added to the streams in JSON format by providing the product code as key. In Update Product status functionality, product data can be updated only by the authorized actor i.e., the actor possessing the product and a new JSON object is published to the product-data stream with the same key as that of add-product functionality. While tracing products, the customer can enter the unique product code to fetch all the details related to the product. While tracing, the array of objects with product code as key is retrieved from the product-data stream and these objects are combined to create a summarized object containing all the details of the product and this JSON object is sent to the Front-End using REST API.

Chapter 4

System requirement and specification

4.1 Introduction

Intended Audience and Reading Suggestions:

The intended audience includes developers, testers, producers, customers, and all the other actors in the Supply Chain. This SRS document is written to help us to verify and validate our project. It will be used by developers and testers to check whether the requirements are met. It also serves as a user manual for all the actors in the Supply Chain.

4.2 User Classes and Characteristics

The major User classes in System would be:

1. Producer or Manufacturer: Producer can accept the order, verify organic quality and update the status of order.
2. Customer: Customers can view all the transactions related to the product by querying Order ID/ Product ID.
3. Dispatcher: The dispatcher will accept product from the manufacturer and transfer it to transportation.
4. Distributors: Receive a product from the producer/manufacturer and can sell it to wholesalers.
5. Wholesalers: Receive a product from the dispatcher and can sell it to retailers.
6. Retailers: Receive a product from the distributor and sell it to customers.
7. Transportation Team: Deliver the product from producer to the customer at various stages(entities) (if required).

4.3 Operating Environment

This application can be accessed from a machine which satisfies the following requirements-

- RAM: 1 GB and above.
- Google Chrome: Version 31 and above.
- Internet Connectivity Speed: 1 Mbs and greater

This application will be deployed on Amazon Web Services (AWS) Elastic Compute Cloud (EC2).

4.4 External interface Requirements:

User Interfaces:

1. User interface will be web page which consists sign-in and sign-up option,

where user need to sign-up on the on the system before performing the operations.

Hardware Interfaces:

1. Client PC with Internet Connection.

Software Requirement :

1. Any Web Browser

4.5 Design and Implementation Constraints

This particular project has been developed on Amazon AMI 2.0 with the inclusion of certain libraries (mentioned in section 3.3 Software Interfaces). The execution of the project is constrained by a machine that satisfies the above-mentioned specifications or any machine which includes specifications similar to the above ones.

4.6 User Documentation

User Documentation components such as user-manuals and tutorials for offline support will be included along with the application.

4.7 Assumptions and Dependencies

It's assumed all stakeholders are well acquainted with GUI and the basic usage of this Web application.

The actors must be well acquainted with using a keypad for updating product-related information.

4.8 Functional Requirement

A. Product Traceability

The product will move through various phases of the Supply Chain. Each product will have a unique product ID which will serve as the primary attribute of the product, along with several other attributes like price, raw materials, producer's details, etc. As the product moves through different actors in the Supply Chain, the transactions will be recorded on the blockchain along with the date and time of the transaction. The product can be traced by all the stakeholders.

B. Add Product

The system allows the producer to add new products and enter them in the Supply Chain. The addition of a new product will lead to the deployment of a new smart filter on the blockchain where all the transactions of the product will be recorded.

C. Update Status

The actor will be able to update the product's status and transfer it to the next actor in the Supply Chain. The actor will verify quality and then send it to the next actor if the product is quality compliant.

D. Actor Registration

Actors except Customers need to be registered to be able to perform functions in the application.

E. Actor Sign-in

Actors except Customers need to be signed in into the application to be able to perform functions in the application.

F. Actor Update Profile

Actors except Customers need to be able to update profile.

4.9 Other Non-functional Requirements

A. Performance Requirements

- The desktop application is supposed to give optimum performance if the requirements mentioned in Section 2.4 and Section 3 have been met.
- The application is hosted on AWS EC2 to auto-scale in case of increase in load on the system.

B. Security Requirements

- The application protects the privacy of the users as all the users will be treated anonymously and as the system is decentralized, user's data is well protected and not shared with third parties. The transaction on the blockchain will be stored in a tamper-proof environment and are encrypted at rest.
- Only the actor possessing the product is allowed to make the changes.
- The user is authenticated on sign on.

C. Software Quality Attributes

Usability

- The software must have a simple and user-friendly Interface.
- The navigation to various pages should make it more convenient to the users so as to save time and confusion.

Maintainability

- Application maintenance should be done regularly to facilitate smooth functioning of the system established.

Reliability

- Information stored in blockchain can never be deleted and serves as a verifiable and accurate record of every transaction made within the smart contract.

Availability

- The application is having high uptime due to auto-scaling feature in AWS.
- Crash fault tolerant.

- Liveness: All nodes will eventually agree on a value as opposed to looping infinitely.

Portability

- Application can be accessed from any device having a web browser and having an active Internet connection.

4.10 Business Rules

1. Manufacturers: Manufacturers add products to the system and will have access to the transactions of that product as recorded on the blockchain and can update the status of the product.
2. Dispatcher: Can track products and update product information.
3. Distributors: Can track products and update product information.
4. Wholesalers: Can track products and update product information.
5. Retailers: Can track products and update product information.
6. Customers: Customers can track the product without authentication.

4.11 Document Conventions

1. Dapps: Decentralized Application.
2. GUI: Graphical User Interface.
3. AWS: Amazon Web Services
4. AMI: Amazon Machine Image
5. EC2: Elastic Compute Cloud
6. RAM: Random Access Memory
7. API : Application Programming Interface
8. JSON : JavaScript Object Notation
9. RPC: Remote Procedure Call
10. AJAX: Asynchronous JavaScript and XML

4.12 Product Perspective

It helps the organizations dealing with food supply chains to better trace the product in reduced time and costs while still getting a tamper-proof environment.

4.13 Product Function

1. It allows the manufacturer to add new products.
2. It allows the possessor of the actor to update product information.
3. It allows the user to trace product by entering product ID.
4. It authenticates the users on sign-in.
5. It authorizes the actors to make changes to their profile, product information.
6. It manages the user session until the users sign out from the application.
7. It allows the user to change their password.

Chapter 5

Project Analysis and Design

5.1 Diagrams

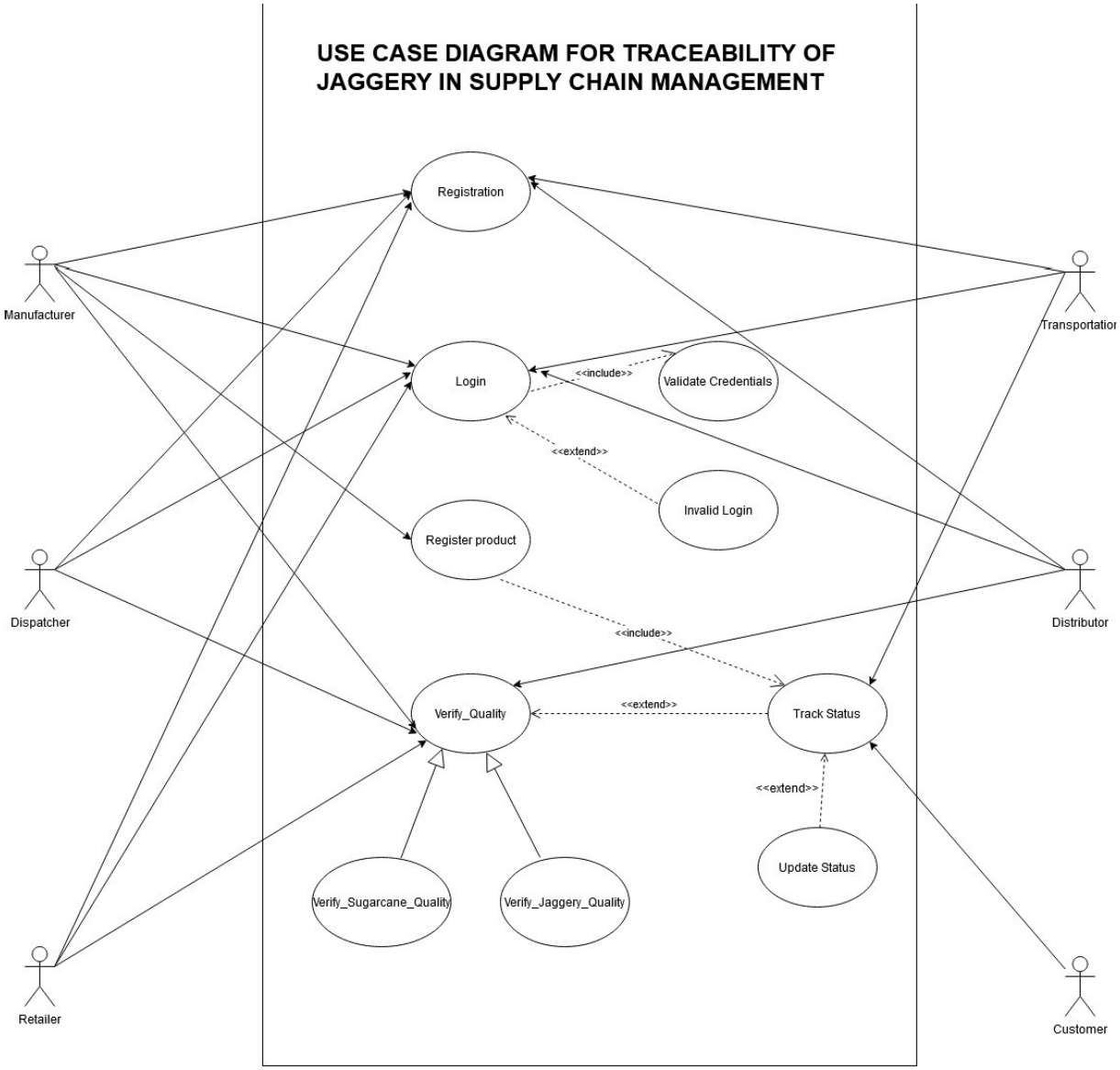


Figure 4 Use Case Diagram

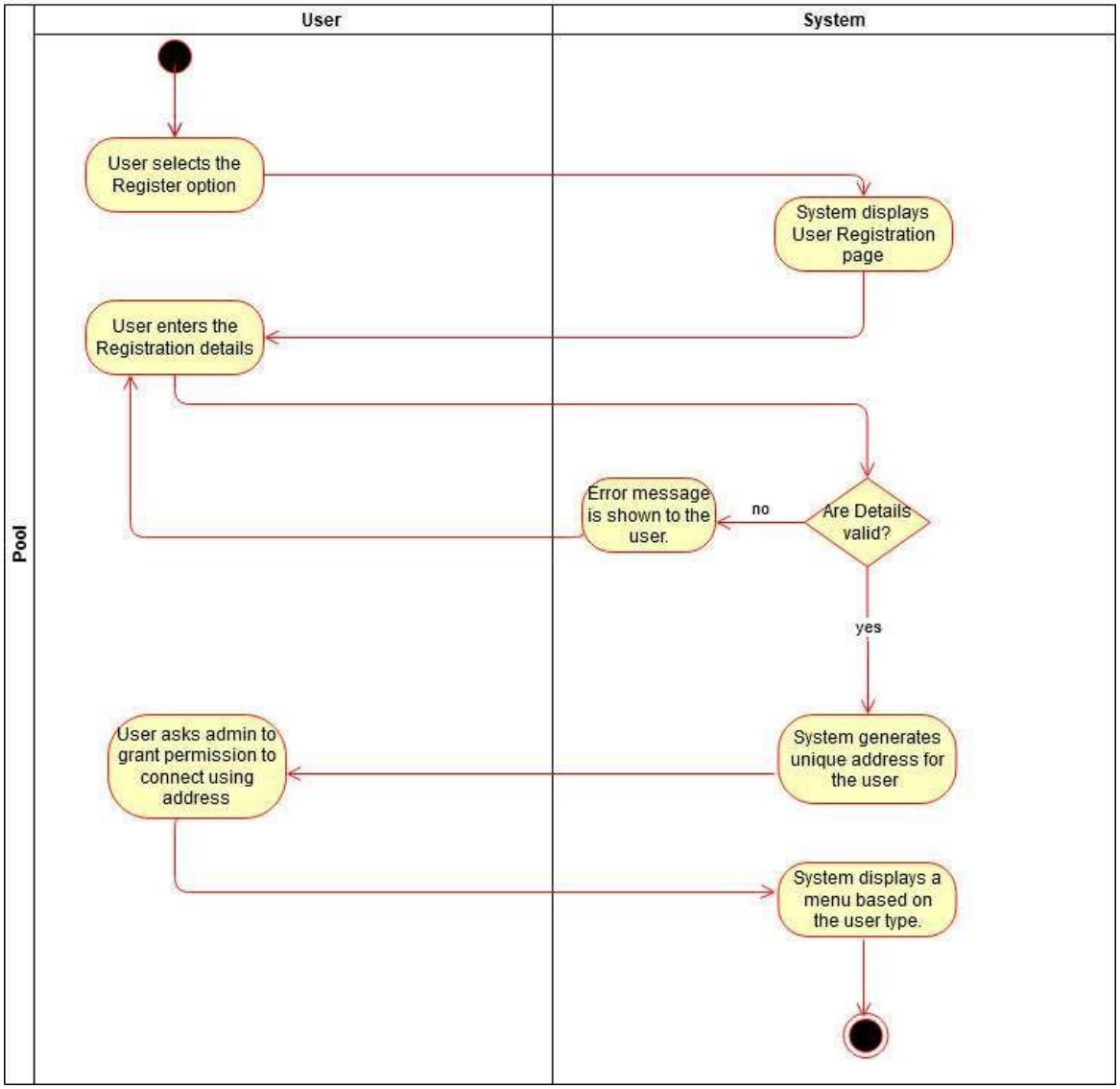


Figure 5 Activity Diagram for User Registration

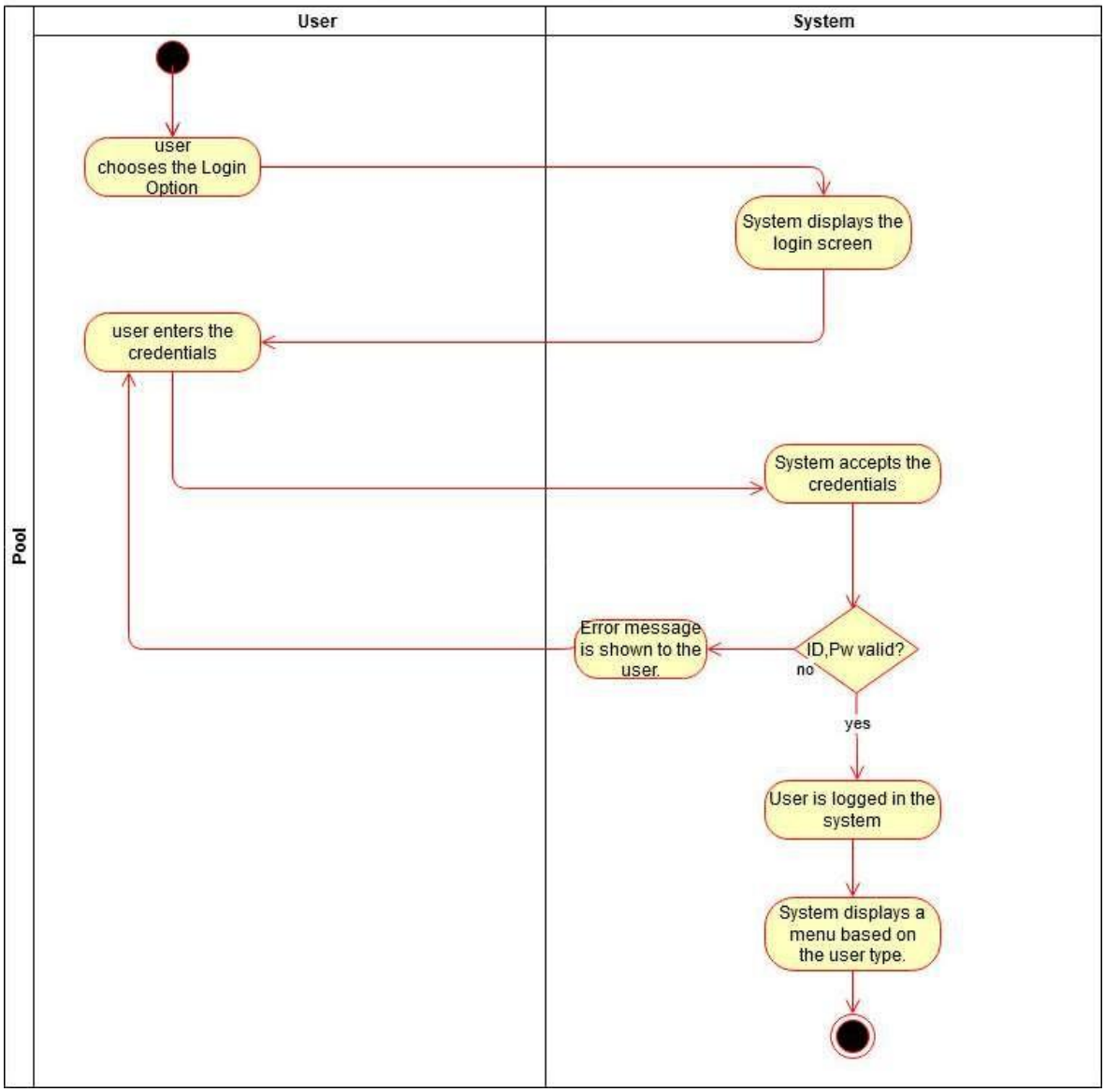


Figure 6 Activity Diagram for Login

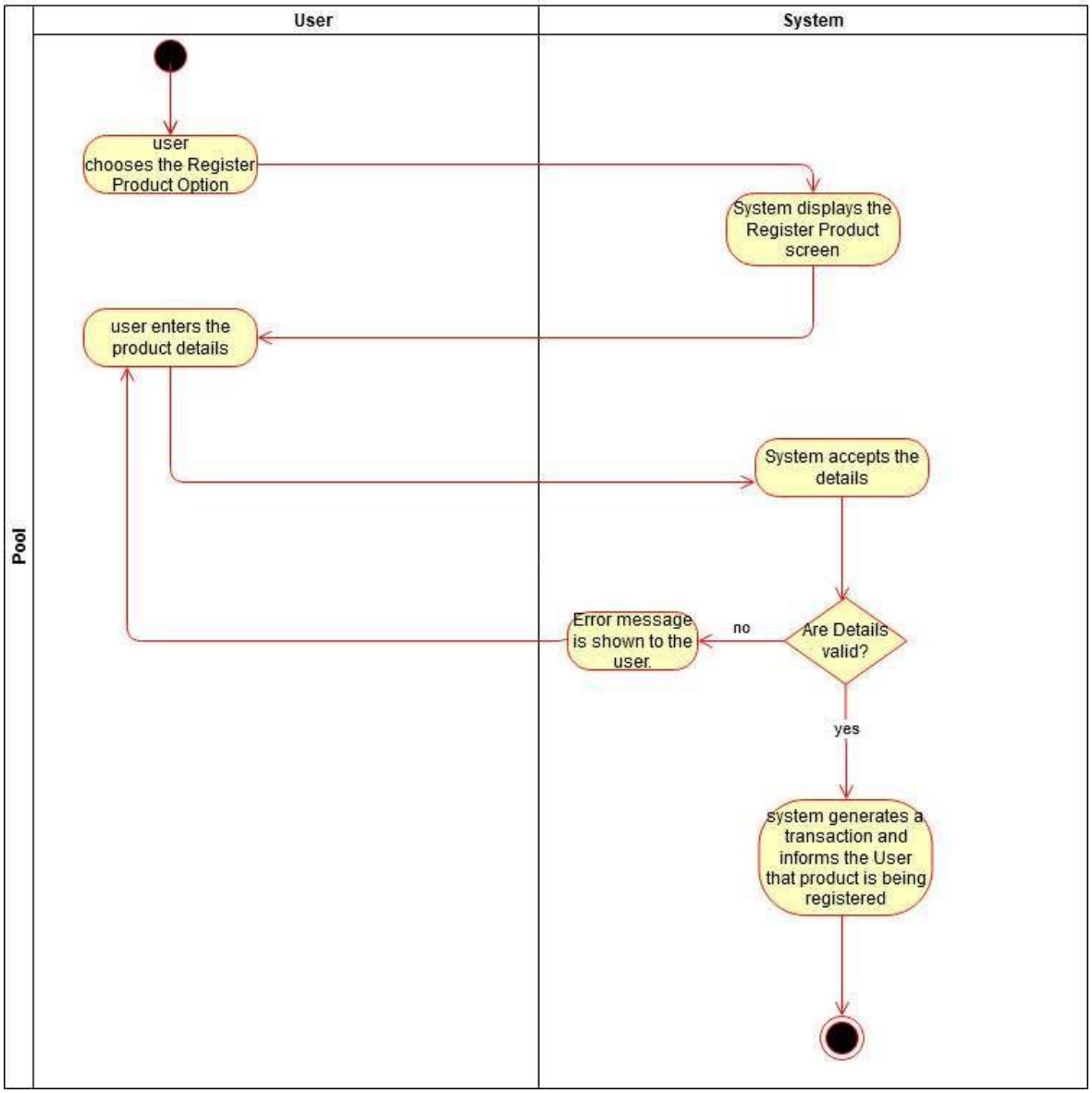


Figure 7 Activity Diagram for Product Registration

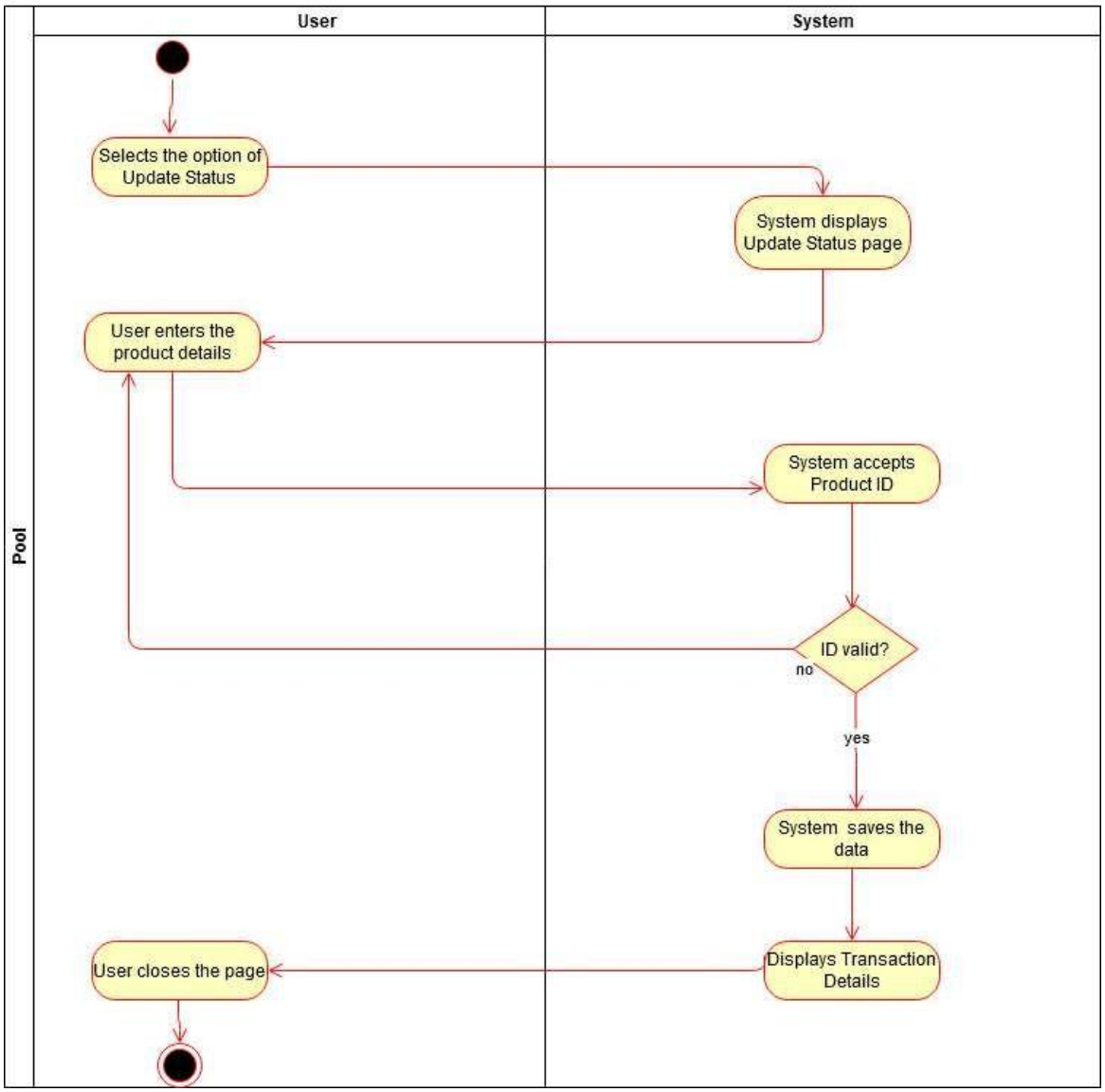


Figure 8 Activity Diagram for Update Product Status

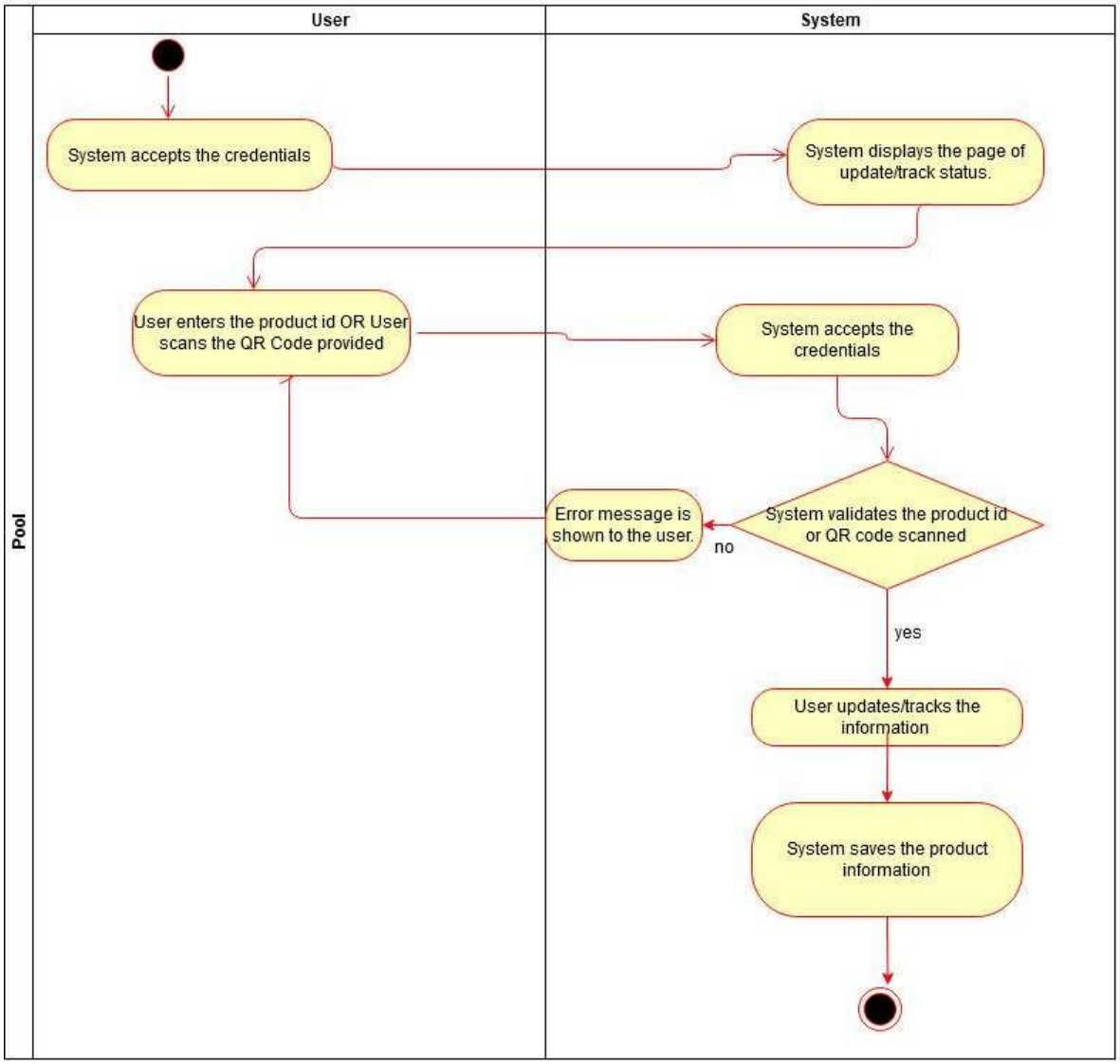


Figure 9 Activity Diagram for Trace Product

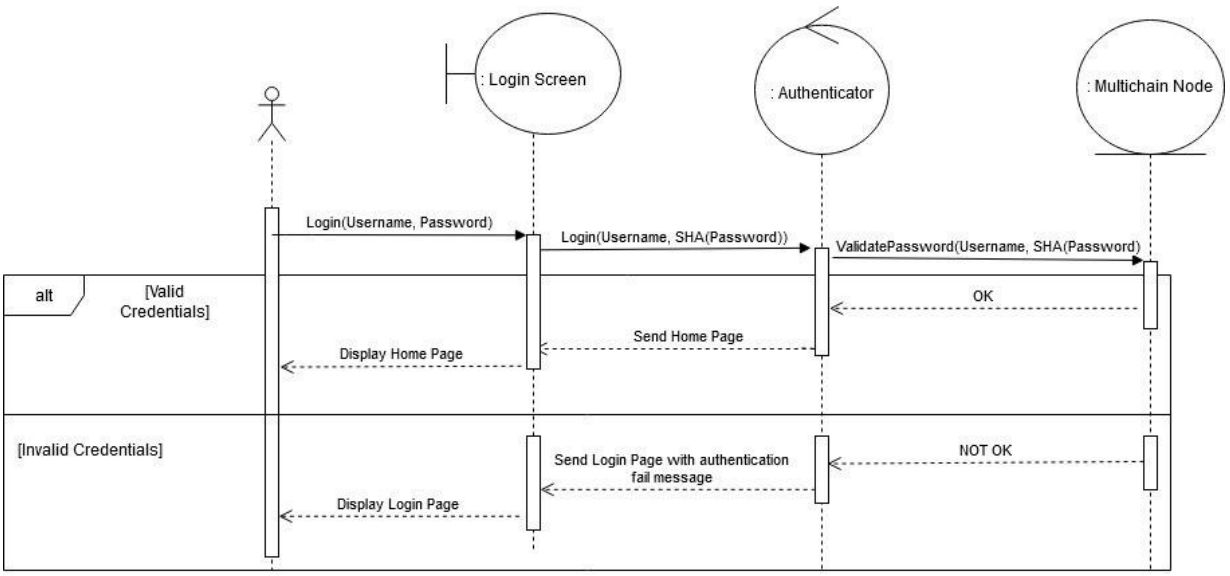


Figure 10 Sequence Diagram for User Login

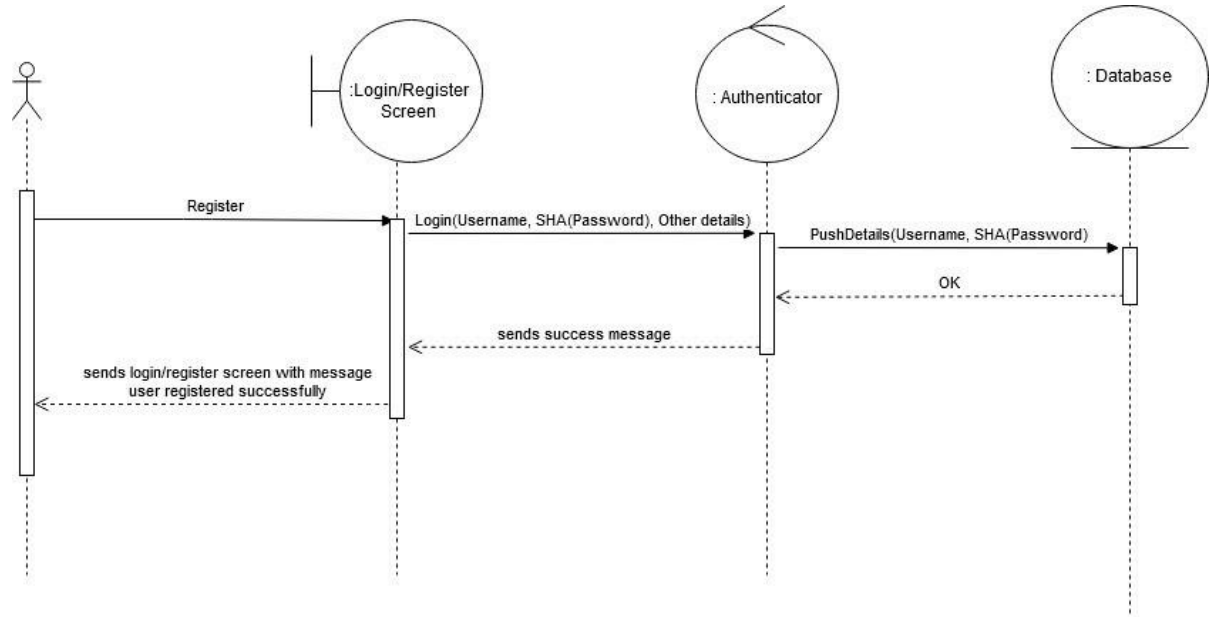


Figure 11 Sequence Diagram for User Registration

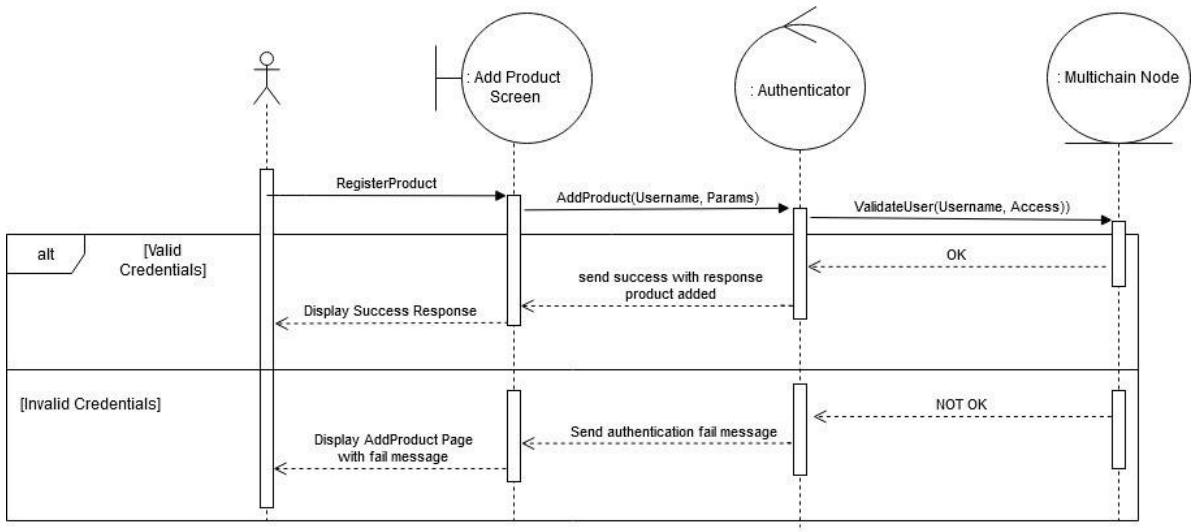


Figure 12 Sequence Diagram for Product Registration

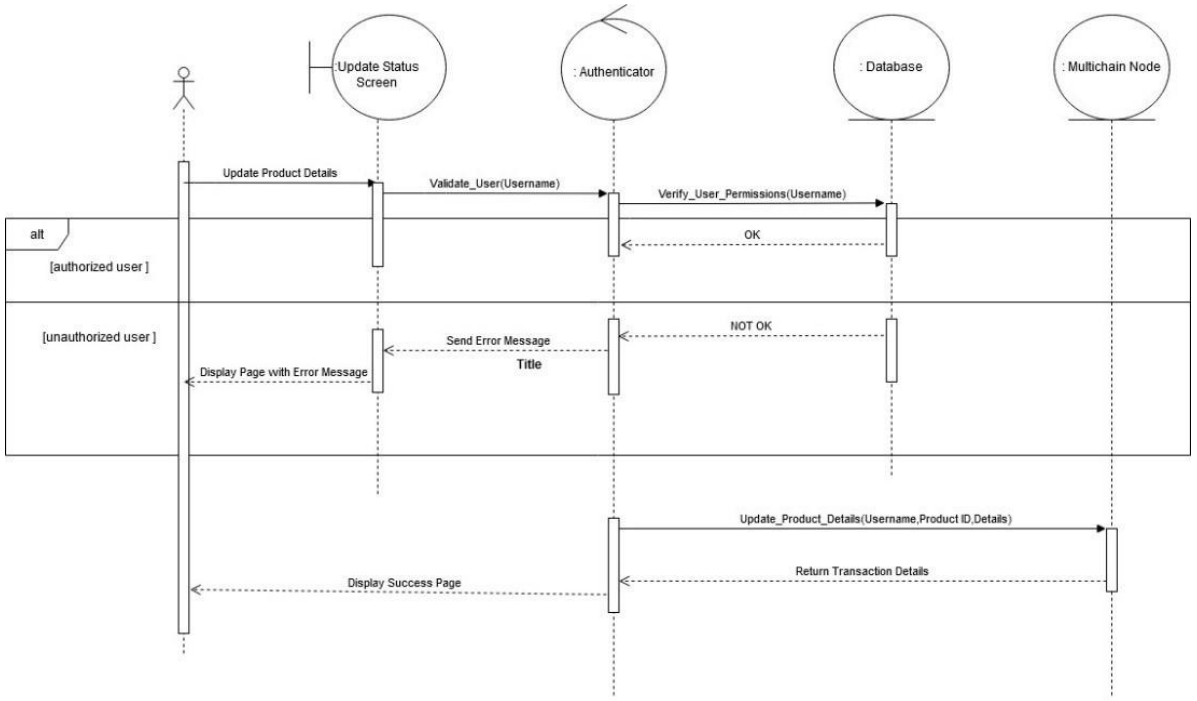


Figure 13 Sequence Diagram for Update Product Status

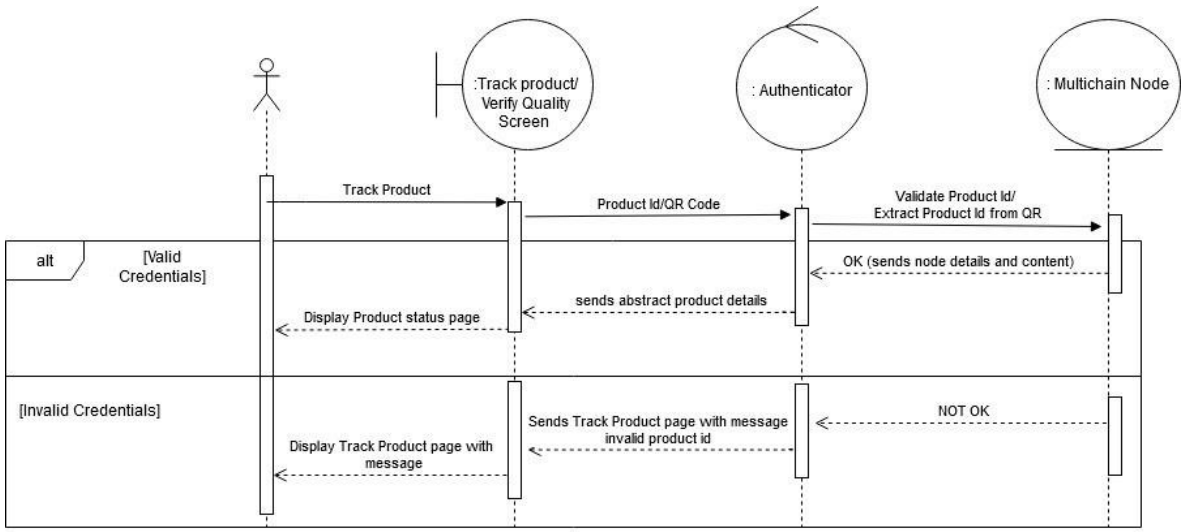


Figure 14 Sequence Diagram for Trace Product Status

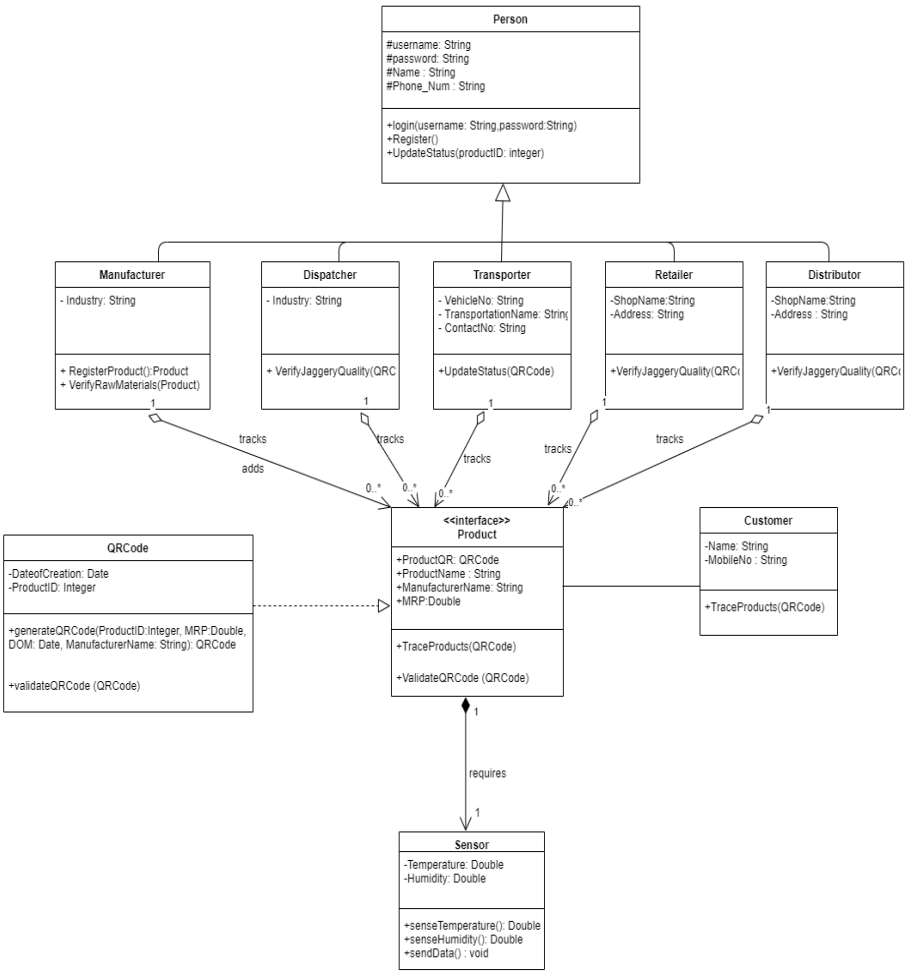


Figure 15 Class Diagram

5.2 Time Schedule

Week	Activity Planned	Activity Completed Status
1.	Registration of Group and learning Blockchain	Completed
2.	Allocation of Guide and Project Topic Submission	Completed
3.	Submission of Abstract to Project Guide and Project Coordinator in the Prescribed Format	Completed
4.	1. Project Review 0 2. Creation of SRS	Completed
5.	Study of Supply Chain and identify process attributes	Completed
6.	1. Creating Front End for the application 2. Learning Multichain	Completed
7.	1. Learning and creating APIs 2. Project Review 1	Completed
8.	Connecting Front-End to NodeJS server using AJAX calls	Completed
9.	Connecting NodeJS to Multichain using JSON-RPC API Login and Register Functionality	Completed
10.	Session Management for Authenticated users	Completed
11.	1. Handling corner cases and other invalid inputs 2. Migrating to the cloud and performing thorough testing	Completed
12.	Documentation and Paper Writing	Completed

Table 1: Project Time Schedule

5.3 Interface Details and Screenshots

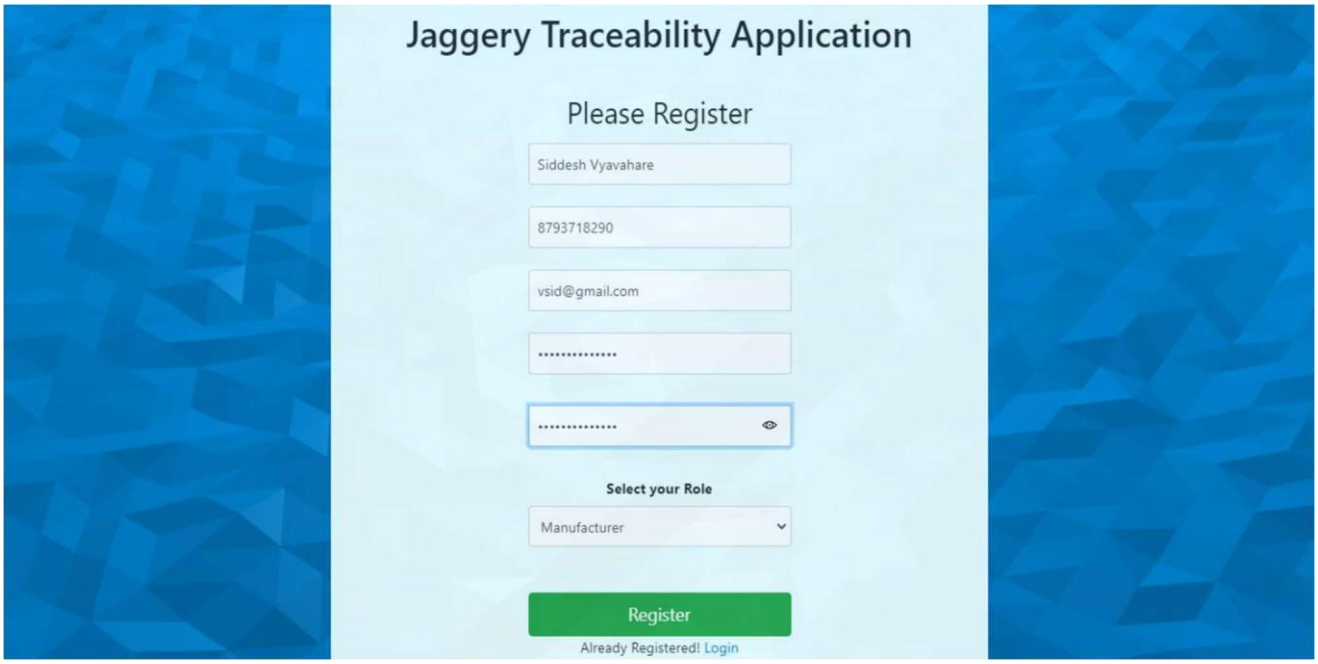


Figure 16 User Registration Page

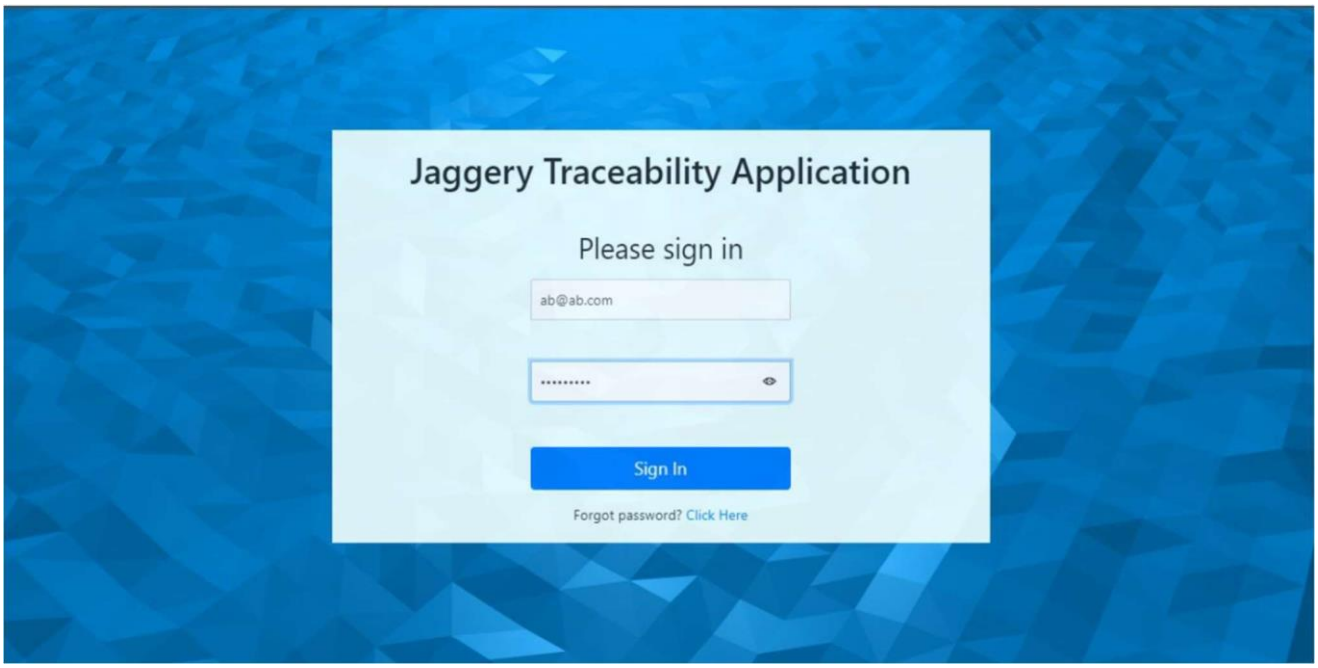


Figure 17 User Login Page

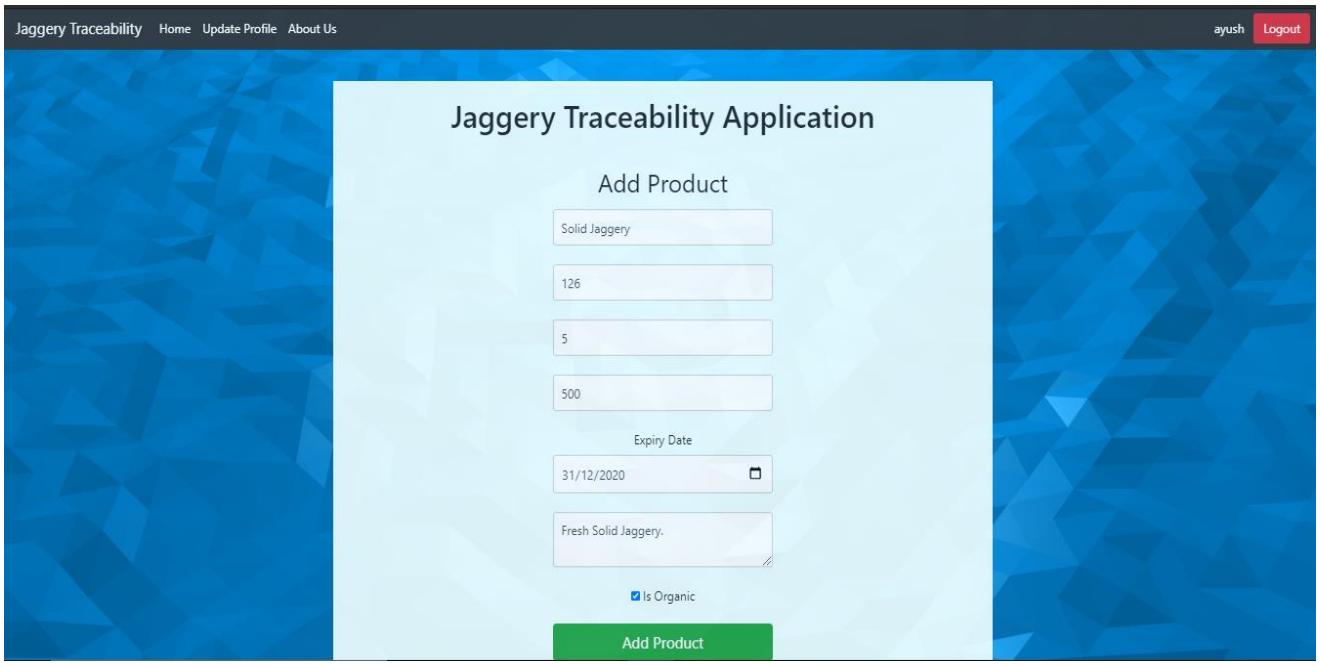


Figure 18 Adding product by Manufacturer

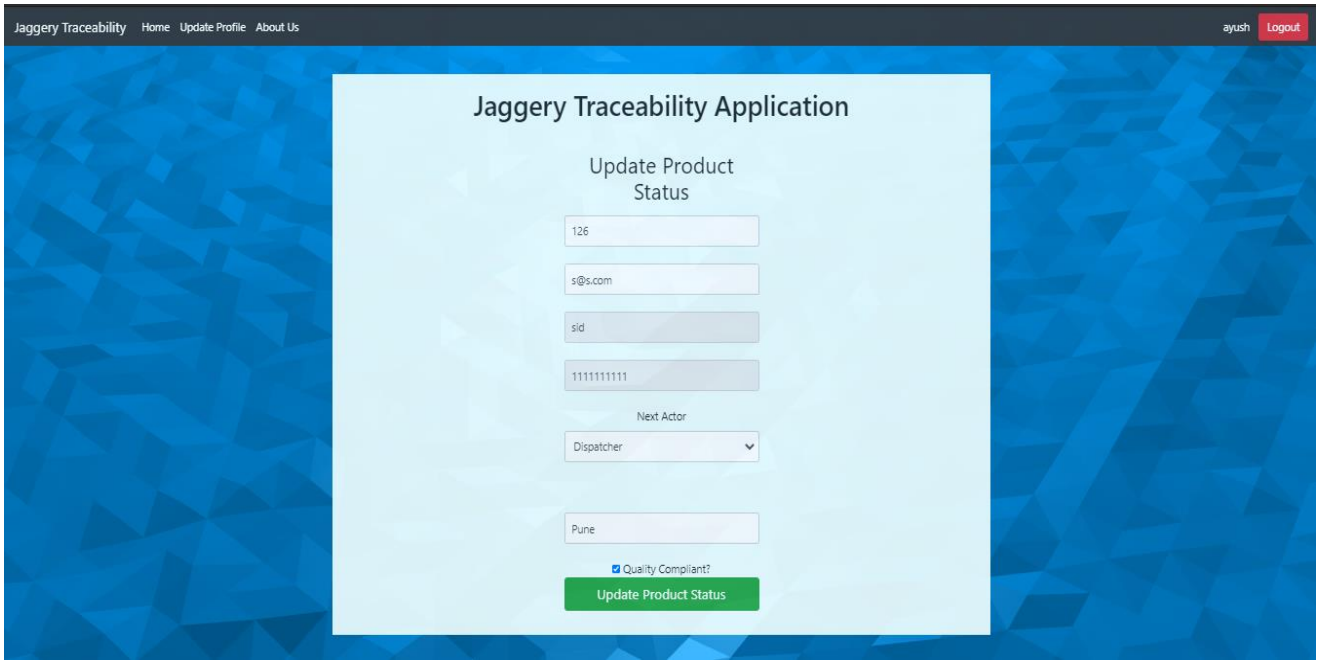


Figure 19 Updating product status by Actor 1

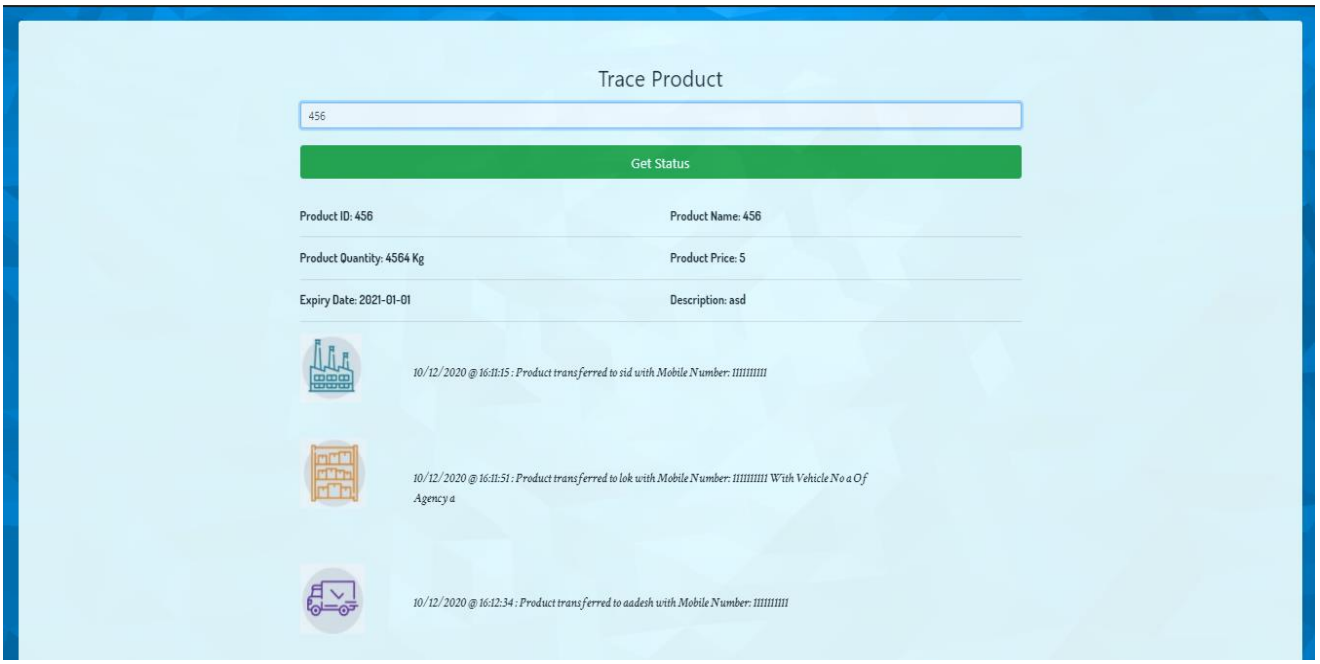


Figure 20 Trace Product

5.4 Performance Evaluation

This project overcomes the shortcomings of the traditional complex pen-and-paper based supply chain as well as central database stored supply chain.

Here, we will evaluate the performance of our product in comparison with the above-mentioned supply chains.

- **Security:**
  In the central database managed supply chain, the database owner/administrator has the entire control over the data and can modify the data or even delete it.
  The blockchain is inherently tamper-proof due to use of cryptographic hashing algorithms, thus no one can make changes without proper authorization.
  This also transforms the untrusted environment into trusted environment.

- **Reduction in time to trace the product:**
  In case of any product mis happenings, the product must be traced back to the source to find the location where quality was tampered.
  In such examples, the time taken to trace the product to the source takes between several weeks and several months.
  Using blockchain technology, this time is reduced to fewer seconds.
  For example, IBM's FoodTrust can trace product in record 2.2 seconds.

- **Reduction in cost to trace the product:**
  In case of any product mis happenings, the product must be traced back to the source to find the location where quality was tampered.
  In such examples, the cost taken to trace the product to the source takes somewhere thousands of dollars to millions of dollars.
  Using blockchain technology, this cost contains only the upfront cost of purchasing a server.

- **Fault-tolerant:**
  As each and every node participates in the blockchain network, each node has their own ledger i.e., the set of transactions performed on the blockchain.
  Hence, even if some of the nodes are down, the transactions can be performed and stored on the nodes active in the network.
  When other nodes join the network, they can get an updated ledger from active nodes.

Chapter 6

Software Testing

6.1 Introduction

This document is a high-level overview defining our testing strategy for the web-based application. Its objective is to communicate project-wide quality standards and procedures. It portrays a snapshot of the project as of the end of the planning phase. This document will address the different standards that will apply to the unit, integration and system testing of the specified application. We will utilize testing criteria under the white box, black box, and system-testing paradigm. This paradigm will include, but is not limited to, the testing criteria, methods, and test cases of the overall design.

6.1.1 Purpose

This document is intended to meet the following objectives:

1. The strategy, responsibilities and schedule for the overall testing.

2. Identify the project and software artefacts that should be tested.

3. List the scope of testing.

4. List the deliverables of the test phases.

5. List the set-up required.

6. Identify the tasks and assumptions in the project, if any.

7. Define the evolution criteria.

6.2 Test Objective

The objective of our test plan is to find and report as many bugs as possible to improve the integrity of our program. Although exhaustive testing is not possible, we will exercise a broad

range of tests to achieve our goal. We will be testing a Supply Chain Traceability Application. There will be five key functions used to manage our application: register user, login user, register product, update product status, trace product in the supply chain. Our user interface to utilize these functions is designed to be user-friendly and provide easy manipulation of the data. The application will only be used as a demonstration tool, but we would like to ensure that it could be run from a variety of platforms with little impact on performance or usability.

6.3 Process Overview

The following represents the overall flow of the testing process:

1. Identify the requirements to be tested. All test cases shall be derived using the current Program Specification.
2. Identify which particular test. will be used to test each module.
3. Review the test data and test cases to ensure that the unit has been thoroughly verified and that the test data and test cases are adequate to verify proper operation of the unit.
4. Identify the expected results for each test.
5. Document the test case configuration, test data, and expected results.
6. Perform the test.
7. Document the test data, test cases, and test configuration used during the testing process. This information shall be submitted via the Unit/System Test Report (STR).
8. Successful unit testing is required before the unit is eligible for component integration/system testing.
9. Unsuccessful testing requires a Bug Report Form to be generated. This document shall describe the test case, the problem encountered, its possible cause, and the sequence of events that led to the problem. It shall be used as a basis for later technical analysis.
10. Test documents and reports shall be submitted. Any specifications to be reviewed, revised, or updated shall be handled immediately.

6.4 Test Cases and Results

Sr. No.	Test Case Name	Prerequisites	Action	Excepted Result	Actual Result	Status
1	Login	Username and password should be entered.	Click on login button	Login successful for valid credentials	Successful login	Pass
2	Login	Username and password should be entered.	Click on login button	Login unsuccessful for invalid credentials	Login failed	Pass
3	Register User	All details must be entered	Click on Register button	Successful Registration for correct details	Successful Registration of the User	Pass
4	Register User	All details must be entered	Click on Register button	Registration unsuccessful for invalid credentials	Registration of User failed	Pass
5	Update Profile Validation	All details must be entered	Click on Update Profile button	Alert generated for invalid phone number	Alert generated for invalid phone number	Pass
6	Add Product By the Manufacturer	User must be logged in	Add Product Details and Click on Add Product Button	Product information inserted in Multichain	Product is registered	Pass
7	Add Product By the Manufacturer	User must be logged in	Add Product Details and Click on Add Product Button	Product information not inserted in Multichain as product already exists	Product is not registered	Pass

8	Add Product By any actor excluding Manufacturer	User must be logged in	Add Product Details and Click on Add Product Button	Product information not inserted in Multichain as product already exists	Product is not registered	Pass
9	Update Status by product possessor	User must be logged in and should enter all the details	Click on Update Status Button	Product information inserted in Multichain	Product is updated	Pass
10	Update Status by product possessor	User must be logged in	User enters product details and Click on Update Status Button	Product information not inserted in Multichain as product doesn't exist	Product is not updated	Pass
11	Update Status by Any actor excluding product possessor	User must be logged in and should enter all the details	Click on Update Status Button	Product information not inserted in Multichain as user is not Authorized	Product is not updated	Pass
12	Trace product	User must be logged in and should enter product ID	Click on Trace Product Button	Product information is shown to the user	Product is traced	Pass
13	Trace product	User must be logged in	User enters invalid Product ID and Click on Trace Product Button	Product information is not shown to the user and Error is shown to the user	Product is not traced as product doesn't exist	Pass
14	Change Password	User must do sign in	User enters email id and new password and confirm it	Password must be changed successfully for registered email id	Password changed successfully	Pass

Table 2: Test Cases

15	Change Password Validation	User must do sign in	User enters email id and new password and doesn't confirms it	Alert generated for confirmation of password	Password doesn't changed	Pass

Chapter 7

Conclusion and Future work

7.1 Conclusion

Implementing the Food supply chain using blockchain makes it possible for a system of independent actors to share and trust a record of digital assets, transactions, and information as well as it offers the potential to disrupt and transform existing business models [24]. There are several contributions of this paper to the knowledge of supply chain management evaluation for organic food products. In general terms, this article can help to replace the ongoing methods employed by the industry to trace organic food products in the supply chain, thus leading to an immense decrease in cost and efforts for the producers and making the products cheaper for the customers [24].

7.2 Future Scope

Future supply chains are likely to be more dynamic in nature, and consist of collaborative value networks in which productivity and efficiency are constantly maximised. These future supply chains will be beneficial to organic foods in terms of preservation of quality. In Future of this research, implementation of IoT smart sensors will be included in the supply chain commodities to verify constraints used for quality preservation [25].

7.3 Achievements

1. Research paper submitted and presented in Vishwacon conference 2020

Chapter 8
Reference

[1] The Rise of Blockchain Technology in Agriculture and Food Supply Chains; Blockchain in Agriculture Traceability Systems:A Review.
[2] When Blockchain Meets Supply Chain: A Systematic Literature Review on CurrentDevelopment and Potential Applications.
[3] S. Nakamoto.Bitcoin: A Peer-to-Peer Electronic Cash System. Accessed:Dec. 1, 2018. [Online]. Available: A Peer-to-Peer Electronic Cash System
[4] M. Crosby, P. Pattanayak, S. Verma, and V. Kalyanaraman, ''Blockchaintechnology: Beyond bitcoin,''Appl. Innov., vol. 2, nos. 6–10, p. 71,2016.
[5] R. Neisse, G. Steri, and I. Nai-Fovino, ''A blockchain-based approach for data accountability and provenance tracking,'' inProc. 12th Int. Conf.Availability, Rel. Secur. (ARES), Reggio Calabria, Italy, 2017, p. 14.
[6] G. R. T. White, ''Future applications of blockchain in business and man-agement: A delphi study,''Strategic Change, vol. 26, no. 5, pp. 439–451,Sep. 2017.
[7] M. Casey and P. Wong, ''Global supply chains are about to get better,thanks to blockchain,''Harv. Bus. Rev., vol. 13, pp. 1–6, 2017. Accessed:Sep. 1, 2018. [Online]. Available: https://hbr.org/2017/03/global-supply-chains-are-about-to-get-better-thanks-to-blockchain
[8] K. Toyoda, P. T. Mathiopoulos, I. Sasase, and T. Ohtsuki, ''A novel blockchain-based product ownership management system (POMS) for anti-counterfeits in the post supply chain,''IEEE Access, vol. 5,pp. 17465–17477, 2017.
[9] Pincheira Caro, Miguel Rodrigo & Ali, Muhammad Salek & Vecchio, Massimo & Giaffreda, Raffaele. (2018). Blockchain-based traceability in Agri-Food supply chain management: A practical implementation. 1-4. 10.1109/IOT-TUSCANY.2018.8373021.
[10] Tripoli, Mischa & Schmidhuber, Josef. (2018). Emerging Opportunities for the Application of Blockchain in the Agri-food Industry.
[11] Lierow, M. Herzog, C. & Oest P. 2017. Blockchain: The Backbone of Digital Supply Chains. Oliver Wyman. Accessed 24 October 2017 http://www.oliverwyman.com/our-expertise/insights/2017/jun/blockchain-thebackbone-of-digital-supply-chains.html.
[12] Gandino, Filippo & Montrucchio, Bartolomeo & Rebaudengo, Maurizio & Sanchez, Erwing. (2009). On Improving Automation by Integrating RFID in the Traceability Management of the Agri-Food Sector. Industrial Electronics, IEEE Transactions on. 56. 2357 - 2365. 10.1109/TIE.2009.2019569.
[13] C cheng
[14] Tribis, Youness & El Bouchti, Abdelali & Bouayad, Houssine. (2018). Supply Chain Management based on Blockchain: A Systematic Mapping Study. MATEC Web of Conferences. 200. 00020. 10.1051/matecconf/201820000020.
[15] Chang, Yanling & Iakovou, Eleftherios & Shi, Weidong. (2019). Blockchain in global supply chains and cross border trade: a critical synthesis of the state-of-the-art, challenges and opportunities. International Journal of Production Research. 58. 1-18. 10.1080/00207543.2019.1651946.
[16] Manski, Sarah. (2017). Building the blockchain world: Technological commonwealth or just more of the same?. Strategic Change. 26. 511-522. 10.1002/jsc.2151.
[17] https://www.cbinsights.com/research/blockchain-vc-ico-funding
[18] Kamath, Reshma. (2018). Food Traceability on Blockchain: Walmart's Pork and Mango Pilots with IBM. The Journal of the British Blockchain Association. 1. 1-12. 10.31585/jbba-1-1-(10)2018.
[19]E. Hofmann, U. M Strewe, and N Bosia, Supply Chain Finance and Blockchain Technology: The Case of Reverse Securitisation. Cham, Switzerland: Springer Nature, 2018. Available: http://link.springer.com/10.1007/978-3-319- 62371-9
[20] Balfegó Group. (2017). Retrieved from https://balfego.com/ca/trasabilitat/
[21] Ripe.io (2017). Retrieved from https://www.ripe.io/media/2019/6/20/the-blockchain-of-food

[22]Greenspan, G. (2015). MultiChain Private Blockchain. Available online at: https://www.multichain.com/download/MultiChain-White-Paper.pdf
[23] Alexandre T. Simon, Sílvio R. I. Pires*, Luis C. Di Sério, A METHODOLOGY FOR EVALUATING THE SUPPLY CHAIN MANAGEMENT USING A CONCEPTUAL MODEL AS REFERENCE [004-0099]. Available: https://www.pomsmeetings.org/confpapers/004/004-0099.pdf
[24] CHRISTINE LEONG, TAL VISKIN, ROBYN STEWART**,** Accenture. (2018) TRACING THE SUPPLY CHAIN How blockchain can enable traceability in the food industry. Available: https://www.accenture.com/_acnmedia/pdf-93/accenture-tracing-supply-chain-blockchain-study-pov.pdf
[25] N. Nasurudeen Ahamed, Karthikeyan P, S.P.Anandaraj, 4Vignesh R, SeaFood Supply Chain Management Using Blockchain. Available: https://www.researchgate.net/publication/340886609_Sea_Food_Supply_Chain_Management_Using_Blockchain