Authenticity in Food Supply Chain using Blockchain

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DECLARATION

We hereby declare that the work reported in 5th semester Minor project entitled "**Authenticity in Food Supply Chain using Blockchain**", in partial fulfilment for the award of the degree of B. Tech (CSE) submitted at Jaypee University of Engineering and Technology, Guna, as per the best of our knowledge and belief there is no infringement of intellectual property rights and copyright. In case of any violation, we will solely be responsible.

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CERTIFICATE

This is to certify that the project titled "**Authenticity in Food Supply Chain using Blockchain**" is the bona fide work carried out by Prakhar Srivastava, Pranab Mishra and Saral Handa, a student of B. Tech (CSE) of Jaypee University of Engineering and Technology, Guna (M.P) during the academic year 2020-24, in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology (Computer Science and Engineering) and that the project has not formed the basis for the award previously of any other degree, diploma, fellowship or any other similar tile.

Signature of the Guide

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ABSTRACT

- The food supply chain refers to the processes that describe how food from a farm ends up on our tables. This process includes production, processing, distribution, consumption and disposal of food products such as wheat, lentil, rice, fruits like apple, banana, etc. It is needed by the global community to maintain defendable and justifiable food security. This continually affects the sensitivity among society, including poor individuals.

- The supply chain now has become longer and complicated and thus involving many challenges like lack of communication among stakeholders, lack of traceability, honesty and transparency, supply of fake food products and failure to monitor warehouses.

- The solution of this problem is important to track, ensure a transparent supply chain, prevent fake food supply, and secure and cashless payments. In this paper, we have talked about the solution of the mentioned problem. In the previous papers, the solutions which have already been encountered are: -

  ❖ **Inadequate communication between parties:**
  Cloud-based networks offer quick onboarding and a range of services for food companies, including a view of the full end-to-end, supply chain, near real-time view into demand, supply, and logistics; and tools to communicate, including live chat and micro-blogging solutions similar to Twitter. This makes it easy to communicate with suppliers and other partners either privately or as a group, formally in a structure way, or informally and unstructured as in live chat. (Asaad, 2022)

  ❖ **Electronic data capture:**
  The process of storing data in electronic form and exchanging it between trading partners is known as electronic data capture. It is such a language that coordinates businesses

electronically. The recording of data electronically in a supply chain ensures safety, transparency, and tracking over the supply chain. It provides the link between parties to examine activities of each other resulting in cost reduction, efficiency, smooth flow, accuracy, and security. (Technologies, 2022)

❖ **Tracking and Traceability:**
The emergence of the Internet of Things (IoT) enhances the pervasive presence of 'things' or 'objects' with RFID tags, sensors and actuators interacting or participating on a network (Atzori et al. 2010). This can benefit the food industry and improve aspects such as the management of food loss and food waste (Wen et al. 2018). The use of IoT in food chains has also intensified with billions of interconnected devices ranging from mobile tools, equipment and machinery on farms to household appliances and temperature-sensing devices (Rao and Clarke 2019).

- The mentioned problem could be solved by building a decentralized public ledger system that could allow for multiple verifications of the authenticity of products, thus helping to restrain the spread of fake ones with features like transparency, decentralization, and immutability using blockchain.

- It is a novel approach because blockchain stores data for each transaction happening on the network and the data stored on the blockchain is immutable. There is an owner for every product on the blockchain and only the owner of the records can modify the ownership of the products. Every data stored on the blockchain is public and hence easy to track products.

ACKNOWLEDGEMENT

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CHAPTER 1

INTRODUCTION

1.1 Problem Definition

Shyam is a farmer from Uttar Pradesh who specializes in Apple cultivation. Every year his branch sells a bulk of his apple to Ram who owns the Royal Apple Factory in Madhya Pradesh. Ram in return receives an order to export Apple to Charlie who owns Charles packaged foods in Germany. In this whole process these individuals face a lot of challenges like lack of communication between the individuals, fake food supply to Charlie, lack of honesty and transparency between them.

Now in order to successfully build a connection between them, there are certain methods such as:

- Charlie will add details about his crops request inspections at the server using Blockchain to get his products at the right time.
- The contracts between Shyam and Ram as well as between Ram and Charlie are stored on the Blockchain network as smart contracts.
- Relevant stakeholders certify the products with standard certificates once the apples are harvested.
- The branch generates the invoice and requests a pickup.
- The Logistic Company pics these apples up from Shyam's farm and delivers it to warehouse.
- The delivery receipt is updated and made available to all stakeholders on the network.
- Once Ram accepts the consignment, the smart contract between Ram and Shyam is executed at Ram's bank. He will be notified to initiate an open account transfer to launch cash or bank the transaction.
- The details will then be updated on the Blockchain network. Meanwhile Ram is busy making apples to be delivered to Charlie, Apples are inspected and certified as well.
- Ram then issues an invoice to Charlie. Charlie tracks the provenance of the product entirely from where the apples were cultivated to the inspection and insurance details perform accepting the invoice.
- Ram then raises a shipment request with the shipping company.

- Once the bill of lading is uploaded by the shipping company, the smart contract between Ram and Charlie gets executed and Charlie's bank initiates the payment to Ram's Bank. The details are updated on the network, thus Charlie sitting in Germany is able to remotely track the provenance of the apples imported from India.

A typical Agricultural supply chain involves complex interconnected processes between various stakeholders such as producer, inspection and insurance companies' logistics and shipping agencies, banks, manufacturer and importer, before it reaches a consumer sitting in another corner of the globe. However, in this long process there are quite a few challenges, importers find it difficult to track products, to understand the place of origin and quality of the imported product, as the product moves between multiple stakeholders. The ownership information becomes difficult to trace. Centralized bodies especially private agencies that certify crop product, may not be trusted by international importers. Information flow between stakeholders leading to potential delays in downstream decision making. Overall stakeholders lack transparency in this process and lose track of relevant transactions. So how do we tackle these challenges?

1.2 Project Overview

- India is one of the largest food producer and consumer in the world. Despite having a rich raw material base for food products, high food price inflation is becoming a major challenge facing the country. There is a shortage of supply due to issues in the food supply chain.

  The food supply chain is essential for both the food producer and consumers. Such systems are designed to ensure transparency of food handling and process, leading to the high quality of food production. To counter this, the Indian government is offering several incentives to private and foreign investors in the food processing sector reflecting the government's intention to attract investment. There is a need for reforms in the food supply chain to enable India to reach out to its unrealised potential. Blockchain using food supply development services can provide greater visibility into complex steps in a food supply.

Any activity can be documented and stored in the distributed ledger only with consensus among all participating stakeholders, thus making the network more trustworthy than any individual entity. Untrusted stakeholders can transact amongst each other through smart contract without the need for a centralized body. Every stakeholder will have their own copy of the same distributed ledger which enables information access in near real time.

- <u>Challenges faced by Food Supply Chain are: -</u>

  o Poor Communication Between Food Supply Chain Partners.

    If the Covid Era has taught us anything, it's that there are some glaring weaknesses in the global supply chain. When food companies create relationships with materials suppliers and transportation providers on the other side of the planet, things are bound to fall through the cracks when a crisis arises. A single missed deadline somewhere down the supply chain can cause a ripple effect that leads to significant delays. When you are dealing with food, it can lead to spoilage, bacteria growth.

  o The Potential for Food Fraud: -

    In the food companies, this is defined as the intentional adulteration of food by misbranding or counterfeiting, substituting one product for another, using approved additives or enhancement, or intentionally contaminating food with various substances. For example, a supplier might ship cheaper alternatives and charge you the same price. Or, they might inject them with enhancers or additives and not tell you about it.

- **How Blockchain can solve the issues of Food Supply Chain?**

A product's tracking across the supply chain with blockchain transactions can aid in establishing trust among consumers and substantiating claims. Blockchain technology is an immutable and transparent data storage system, which is a constituent component that empowers the Blockchain using Food Supply Chain.

Blockchain Using Raw Material Supply Chain is a lengthy process, which includes supplier, manufacturing, distributor, retailer, and consumer. Each product is relayed through various verified stages and information is recorded

relevant to the product. The recorded data is vital because it provided feedback to the manufacturers as well as consumers about the source and the handling mechanism of the products. Blockchain technology enables digital data to be stored information of products every data block consists of a timestamp, transaction, manufacturer, distributor, retailer, and consumer. Once the data has been verified and added to the blockchain using food supply, the data will be permanently stored on the smart contract.

- **Key Elements of Blockchain: -**

  - **Distributed Ledger Technology –**

Distributed Ledger Technology (DLT) is a protocol that enables the secure functioning of a decentralized digital database. Distributed networks eliminate the need for a central authority to keep a check against manipulation.

DLT allows for storage of all information in a secure and accurate manner using cryptography. The same can be accessed using "keys" and cryptographic signatures. Once the information is stored, it becomes an immutable database and is governed by the rules of the network.

The idea of a distributed ledger is not totally new, and many organizations do maintain data at different locations. However, each location is typically on a connected central system, which updates each one of them periodically. This makes the central database vulnerable to cyber-crime and prone to delays since a central body has to update each distantly located note.

DLT has great potential to revolutionize the way governments, institutions, and corporation's work. It can help governments with tax collection, the issuance of passports, recording land registries and licenses, and the outlay of Social Security benefits as well as voting procedures. The technology is making waves in industries such as finance, music and entertainment, diamond and other precious assets, art, supply chains of various commodities, and more.

In addition to start-ups, many big companies such as IBM and Microsoft are experimenting with the blockchain technology. Some of the most popular distributed ledger protocols are Ethereum, Hyperledger Fabric, R3 Corda, and Quorum.

- **Smart Contracts: -**

A smart contract is a self-executing contract with the terms of the agreement between buyer and seller being directly written into lines of code. The code and the agreements contained therein exist across a distributed, decentralized blockchain network. The code controls the execution, and transactions are trackable and irreversible.

Smart contracts permit trusted transactions and agreements to be carried out among disparate, anonymous parties without the need for a central authority, legal system, or external enforcement mechanism.

- <u>Benefits of Smart Contracts</u>

    - Accuracy, Speed, and Efficiency: -

    The contract is immediately executed when a condition is met. Because smart contracts are digital and automated, there is no paperwork to deal with and no time was spent correcting errors that can occur when filling out documentation by hand.

    - Trust and Transparency: -

    There's no need to worry about information being tampered with for personal gain because there's no third party engaged and Encrypted transaction logs are exchanged among participants.

    - Security: -

    Because blockchain transaction records are encrypted, they are extremely difficult to hack. Furthermore, because each entry on a distributed ledger is linked to the entries before and after it, hackers would have to change the entire chain to change a single record.

    - Savings: -

    Smart contracts eliminate the need for intermediaries to conduct transactions, as well as the time delays and fees that come with them.

- Benefits of Blockchain: -

  o <u>Enhanced security: -</u>

  Your data is sensitive and crucial, and blockchain can significantly change how your critical information is viewed. By creating a record that can't be altered and is encrypted end-to-end, blockchain helps prevent fraud and unauthorized activity.

  o Greater transparency: -

  Without blockchain, each organization has to keep a separate database. Because blockchain uses a distributed ledger, transactions and data are recorded identically in multiple locations. All network participants with permissioned access see the same information at the same time, providing full transparency. All transactions are immutability recorded, and are time- and date-stamped.

  o Increased efficiency and speed: -

  Traditional paper-heavy processes are time-consuming, prone to human error, and often requires third-party mediation. By streamlining these processes with blockchain, transactions can be completed faster and more efficiently.

  o Automation: -

  Transactions can even be automated with "smart contracts," which increase your efficiency and speed the process even further. Once pre-specified conditions are met, the next step in transaction or process is automatically triggered.

  In this paper a solution has been given on the problem of food supply chain that the individuals are facing that they are getting fake products and security to the stored data that is encrypted, decentralized and cross-checked which permit the data to remain strongly backed.

1.3 Tools and technologies

We have used and worked on following technologies:

• MetaMask - to interact with smart contracts

MetaMask is a popular and established browser extension which functions as a cryptocurrency wallet that connects to the Ethereum blockchain. MetaMask allows users to interact with the Ethereum ecosystem, which hosts a vast universe of decentralized applications (Dapps), without having to download the entire blockchain on their device. As such, it's the one of the best Ethereum wallet solutions for easy access to decentralized exchanges (DEX), gaming platforms, gambling sites and many other applications. The wallet is compatible with the most widely adopted browsers such as Chrome, Firefox, Brave and Microsoft Edge. Apart from storing Ethereum's native currency, ETH, MetaMask also holds tokens that are built on the protocol's ERC-20 and ERC-721 standards.

- Web3.js - for interfacing with the Ethereum blockchain

  Web3.js enables you to fulfil the second responsibility: developingclients that interact with The Ethereum Blockchain. It is a collection of libraries that allow you to perform actions like send Ether from one account to another, read and write data from smart contracts, create smart contracts, and so much more! If you have a web development background, you might have used jQuery to make Ajax calls to a web server. That's a good starting point for understanding the function of Web3.js. Instead of using a jQuery to read and write data from a web server, you can use Web3.js to read and write to The Ethereum Blockchain.

• Truffle – development environment, testing framework for blockchain

  Truffle is a world-class development environment, testing framework and asset pipeline for blockchains using the Ethereum Virtual Machine (EVM), aiming to make life as a developer easier. Truffle is widely considered the most popular tool for blockchain application development with over 1.5 million lifetime downloads. Truffle supports developers across the full

lifecycle of their projects, whether they are looking to build on Ethereum, Hyperledger, Quorum, or one of an ever-growing list of other supported platforms. Paired with Ganache, a personal blockchain, and Drizzle, a front-end dApp development kit, the full Truffle suite of tools promises to be an end-to-end dApp development platform.

• Ganache – local blockchain for Ethereum development

So, to begin with, Ganache is part of the Truffle Suite ecosystem. Specifically, the Truffle Suite consists of Ganache and an additional pair of tools; Truffle and Drizzle. Truffle is a development environment, asset pipeline, and testing framework using the EMV (Ethereum Virtual Machine); meanwhile, Drizzle is a collection of frontend libraries. On the other hand, Ganache is a high-end development tool used to run your own local blockchain for both Ethereum and Corda dApp development. Ganache is helpful in all parts of the development process. The local chain allows you to develop, deploy and test your projects and smart contracts in a deterministic and safe environment.

1.4 Software Specification

- npm
- Operating system: Linux- Ubuntu 16.04 to 17.10

1.5 Hardware Specification

- CPU (3.0 GHz or faster) or faster 64-bit Dual Core processor like Intel core-2 duo.
- Memory: 4GB (DDR4 | DDR2) RAM or more.

CHAPTER-2
LITERATURE SURVEY

A food supply chain is defined by "Many interdependent companies that work closely together to manage the chain of goods, services, and materials along the value-added chain of raw materials and food products".[4] When the food production chain takes place in more vulnerable value chains, which requires more attention over handling processes, such as producing and storing the food. In addition, food tracking and detecting make sure about food safety and quality a challenge in the food supply chain. Food products failure includes food, food poisoning, substandard food, counterfeit products, or improper labelling with unpopular ingredients during food production. Every raw material step and every supplier which is used in a food supply chain matters to the final food products. Therefore, the food supply chain requires closer partner collaboration and higher efficiencies to maintain the value food chain and detect products failure. The modern food supply chain is centralized can threaten the supply chain transparency, which causes information inequality and trust issues. Companies will have to be chosen to open up selected information of the verified raw material which are included in food, that is beneficial to its own brand image. Therefore, customers feel safer by the food products and demands more, after tracking and verifying the products before purchasing. Major food brands often choose to open up partially selected information to the public and aim to benefit companies themselves, which may result in consumers not having enough information about the products and company details of their suppliers, suggesting that insufficient information may contribute to food security. Therefore, using a blockchain has been found to be more transparent, improve information authenticity, and speed up food memory. The complexity of the supply chain can be reduced and operations can be performed automatically using smart contracts. Higher-order and customization, the difference between the application level and the basic system, the direction of the sensory recording in relation to the scalability, the definition of authorization, make the blockchain technology appropriate. one of the key features of the blockchain is the allocation of space in different countries, which allows for authorized users to make transactions and access direct history without intermediate power

interventions. Always the registered official user has the same ability to check the activity, and have a copy of the history.

A brief review of relevant concepts, including Blockchain, decentralization, Smart Contract, and traceability, to provide some background information:

Blockchain: - Nakamoto introduced the concept of the blockchain in a peer-to-peer ledger in 2008. Blockchain is used to save each digital traceability data. It has recently gained so much considerable attention for addressing food supply chain tracking. It has been successfully applied in the financial area and now a day it triggers huge interest in multiple areas, including the food supply chain, property, voting, etc.

Decentralization: -It is different from traditional transactions that need to be approved by any central authorities. Decentralization eliminates the address's details and equal power by allowing direct transactions between users. It will always ensure that every authorized user has equal power within a network and transaction. Users can help each other to validate transactions and have equal power to access transaction history anytime and anywhere. Different stakeholders save the copies of records and store the data, which can be retrieved and shown on-demand anytime.

Smart Contract: -A smart contract is another important aspect of the blockchain, which is a digitalized agreement and operates automatically works once certain agreements have been met. The use of smart contracts can significantly speed up transactions and improve the trust of customers. A planned contract will keep paperwork, speed up processing time, and reduce staffing efforts compared to traditional sales. All of these features of blockchain can eliminate the risk of transactions in the absence of a trusted environment, increase food supply chain visibility and tracking, improve efficiencies, and protect every stakeholder's benefits.

Traceability: - Traceability provides the recording and tracking of products movement, which allows companies and consumers to have a clear view of the supply chain, raw material used in the product, make better decisions, and avoid quality risks. It is considered as an added value of food products. In addition, it is the most attractive tool in marketing to attract customers

and gain customer loyalty. The record is also a point of verification for companies to be sure about the raw material quality is good and verified. Blockchain has been identified as a solution for achieving effective tracking in food supply using some of the research in food tracking.

CHAPTER-3
UML Diagrams

The application follows the layered architecture where components which similar functionality are organized into horizontal layers and each layer has a specific role within the application.

System Architecture
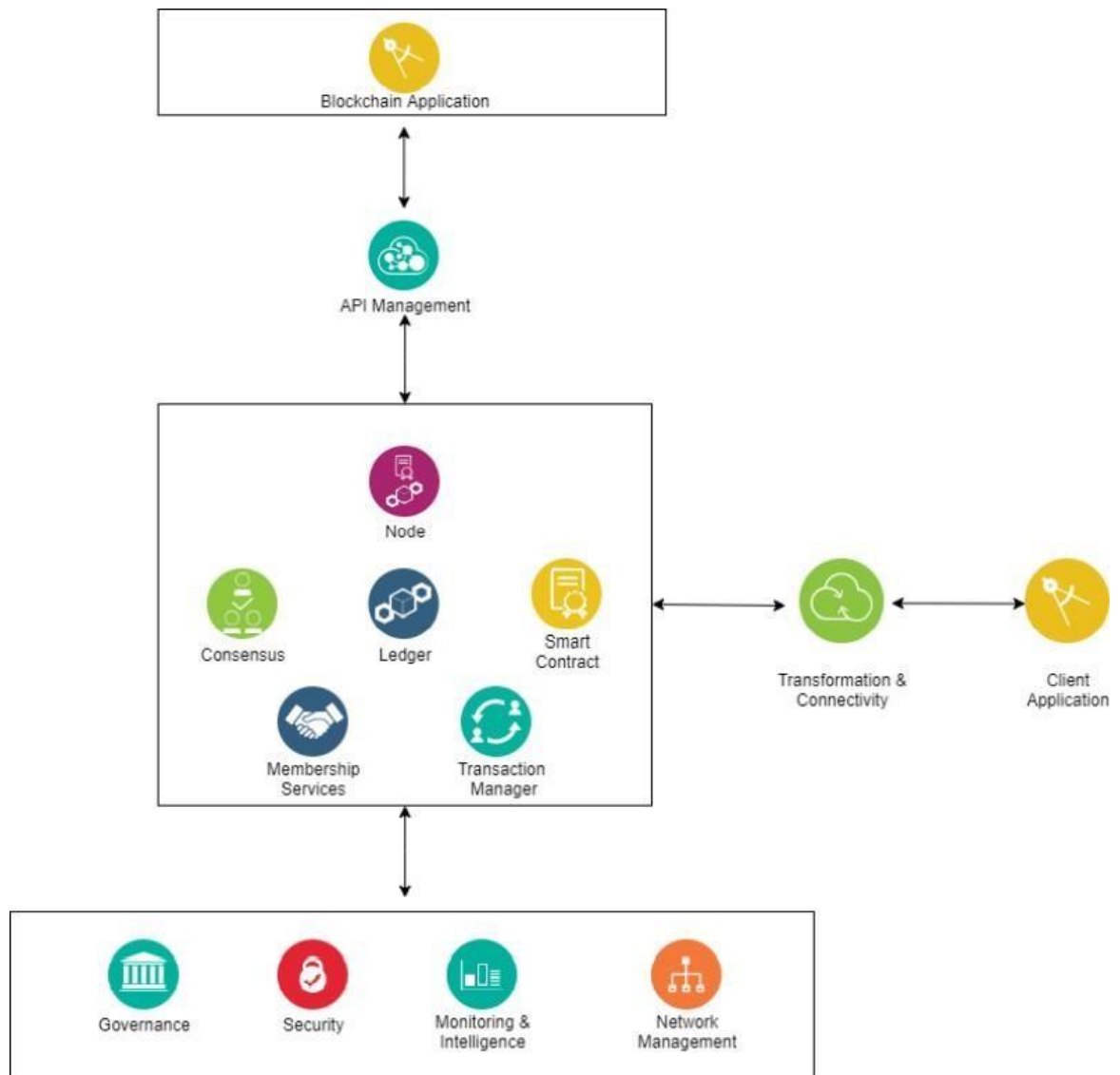
Class Diagram

•This system adds a layer of trust between customers and retailers.

•This mechanism allows only actual customers of the product to post feedback about the product.

•The reviews on the blockchain are immutable which does not allow any merchant or retailer to delete or update bad reviews to increase their overall ratings.
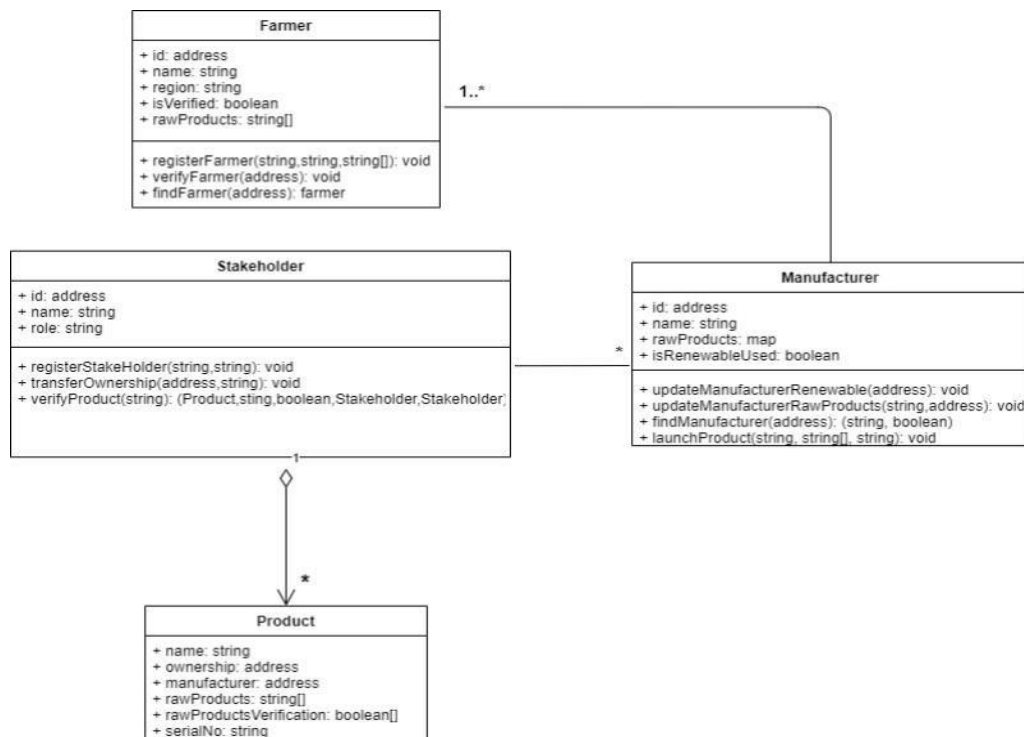
•The process of delivering goods from one entity to another is tracked and recorded on the blockchain.

•The consumers first register themselves on the system and request to purchase the product with a serial number.

•The purchase request is sent to the product owner who updates the product ownership with the new owner.

•This process ensures that retailers do not sell products with duplicate serial codes.
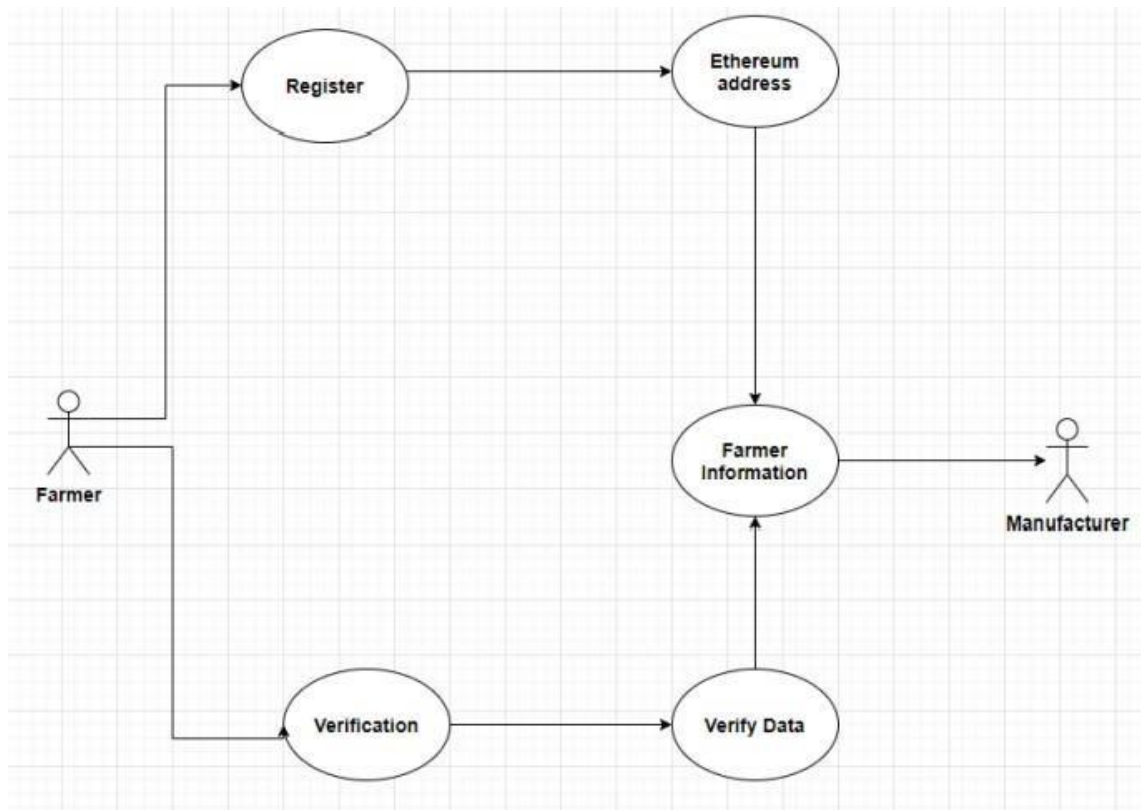
Sequence Diagram (Case: Transfer Ownership): -
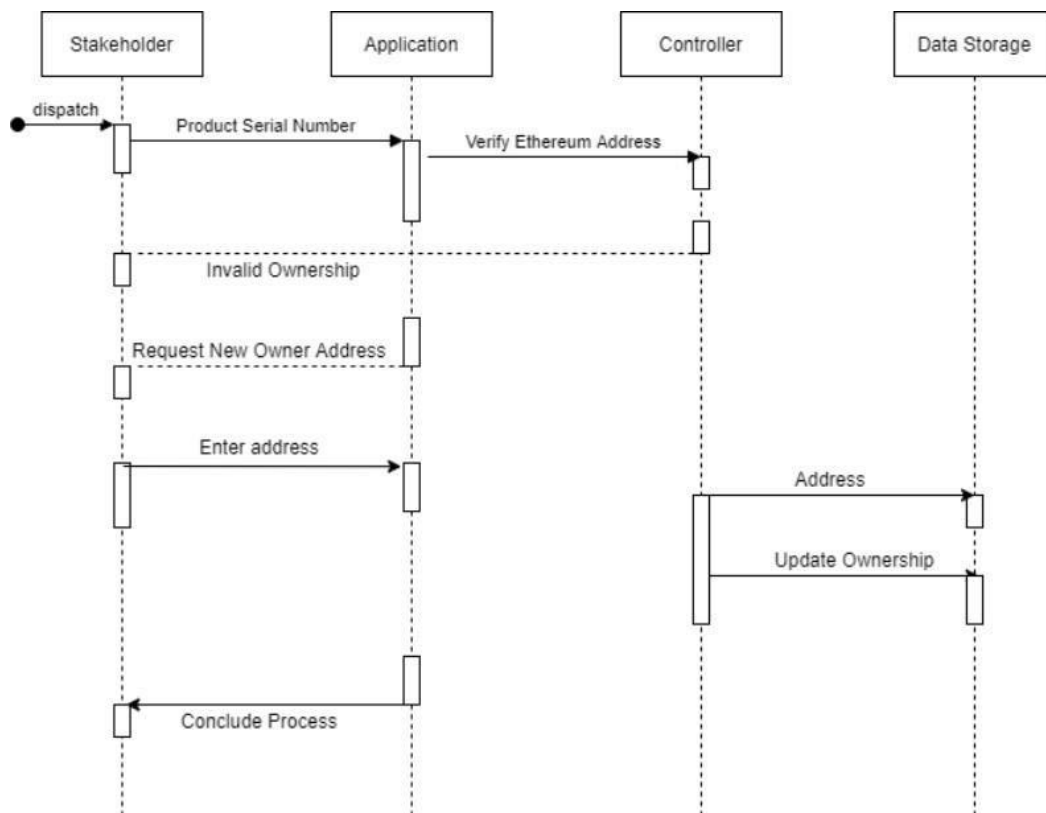
•Each product is marked with unique serial code which is owned by an externally owned account on Ethereum.

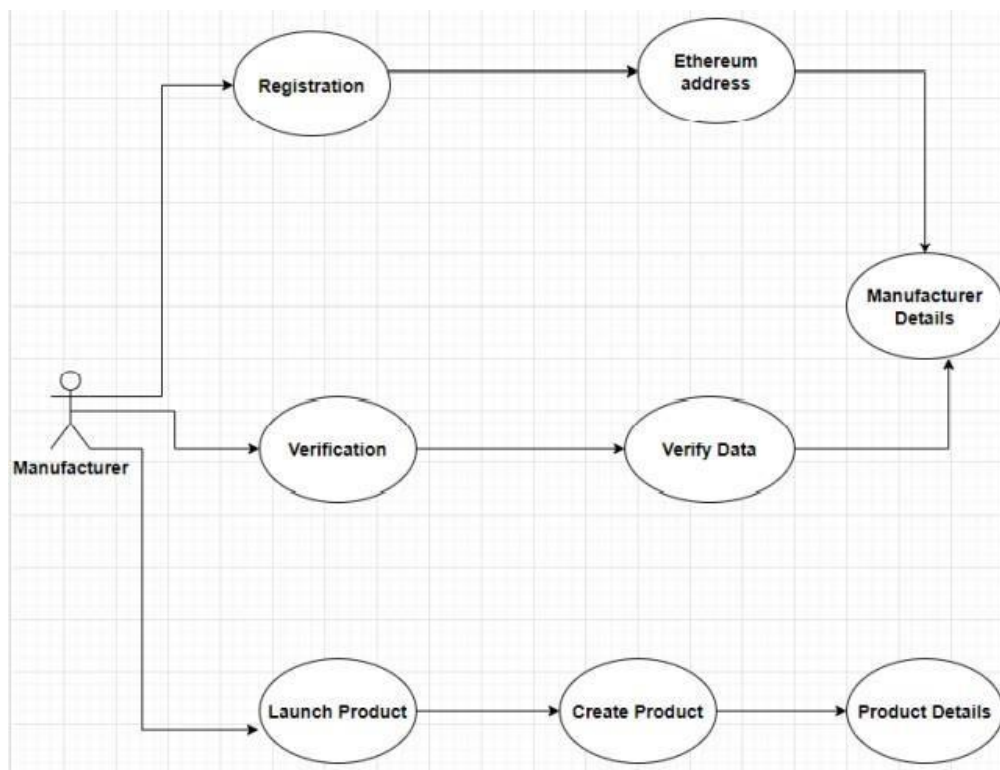•Every product transaction is recorded and stored in smart contract and linked with product's serial code.
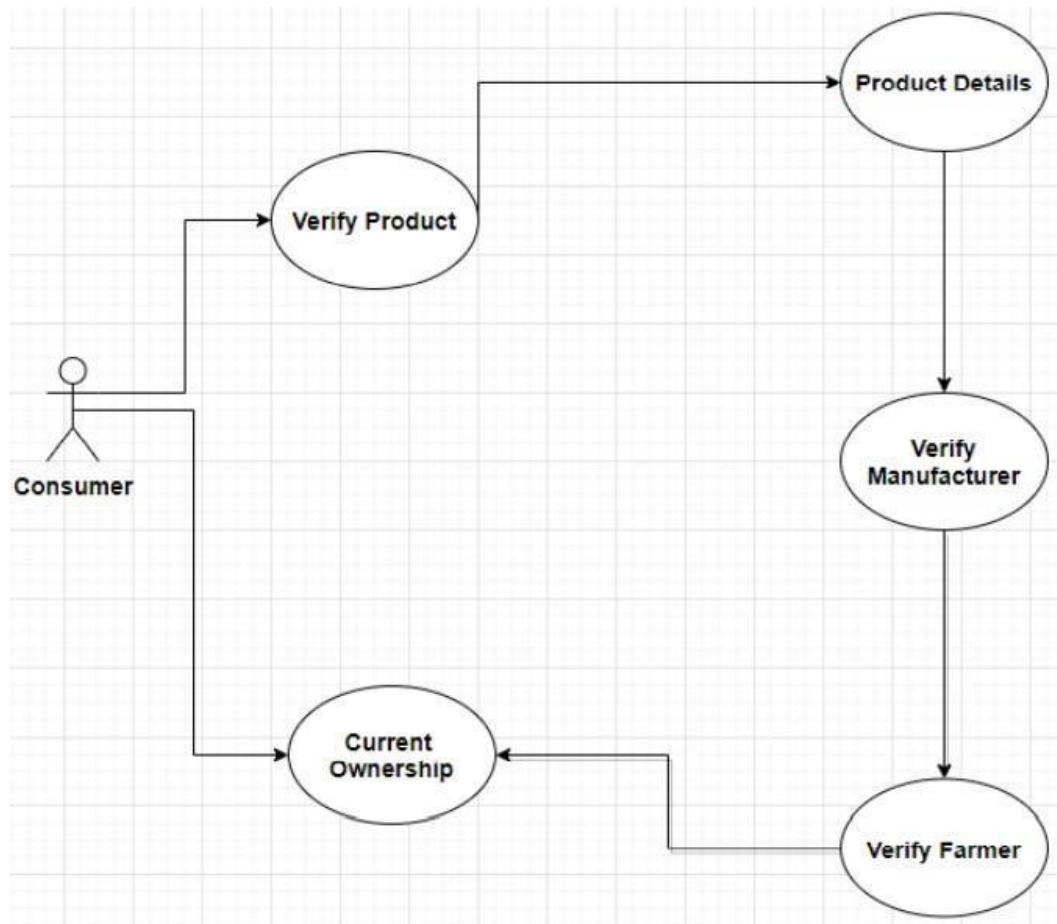
Data Flow Diagram: -
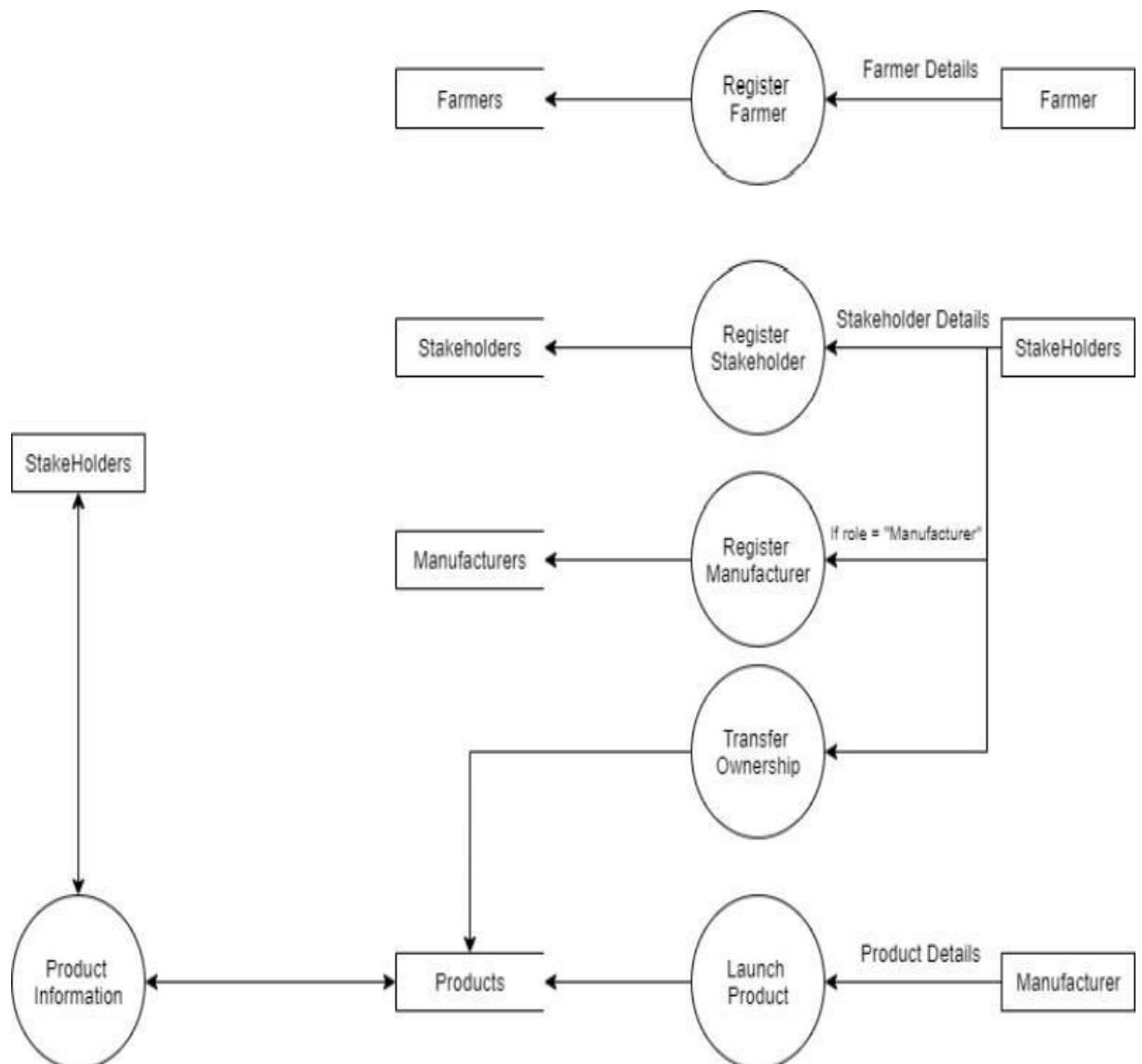
- Use Case Diagram 1: Farmer

- Use Case Diagram2: Manufacturer

- Use Case Diagram3: Consumer

CHAPTER-4
Modules Description

Solidity

Solidity is an object-oriented, high-level programming language used to create smart contracts that automate transactions on the blockchain.
After being proposed in 2014, the language was developed by contributors to the Ethereum project. The language is primarily used to create smart contracts on the Ethereum blockchain and create smart contracts on other blockchains.

Solidity is similar to one of the most common programming languages, JavaScript. It can be considered as a dialect of JavaScript. This means that if you understand JavaScript, it can be easy to pick up Solidity. Solidity also shares similar characteristics to the programming languages C++ and Python.

As a high-level language, Solidity does away with the need to type code in ones and zeros. It makes it much easier for humans to write programs in ways they find easier to understand, using a combination of letters and numbers.

Solidity is statically typed, with support for inheritance, libraries, and complex userdefined types. As Solidity is statically typed, the user much specify each variable. Data types allow the compiler to check for the correct use of variables. Solidity data types are usually categorized as either value types or reference types.

The main difference between value types and reference types can be found in how they are assigned to a variable and stored in the EVM (Ethereum Virtual Machine). While changing the value in one variable of a value type does not affect the value in another variable, anybody referring to changed values in reference type variables may get updated values.

JavaScript

JavaScript is a dynamic programming language that's used for web development, in web applications, for game development, and lots more. It allows you to implement dynamic features on web pages that cannot be done with only HTML and CSS.

Many browsers use JavaScript as a scripting language for doing dynamic things on the web. Any time you see a click-to-show dropdown menu, extra content added to a page, and dynamically changing element colors on a page, to name a few features, you're seeing the effects of JavaScript.

Being a scripting language, JavaScript cannot run on its own. In fact, the browser is responsible for running JavaScript code. When a user requests an HTML page with JavaScript in it, the script is sent to the browser and it is up to the browser to execute it. The main advantage of JavaScript is that all modern web browsers support JavaScript. So, you do not have to worry about whether your site visitor uses Internet Explorer, Google Chrome, Firefox or any other browser. JavaScript will be supported. Also, JavaScript runs on any operating system including Windows, Linux or Mac.

React JS

React.js is an open-source JavaScript library that is used for building user interfaces specifically for single-page applications. It's used for handling the view layer for web and mobile apps. React also allows us to create reusable UI components. React was first created by Jordan Walke, a software engineer working for Facebook. React first deployed on Facebook's newsfeed in 2011 and on Instagram.com in 2012.

React allows developers to create large web applications that can change data, without reloading the page. The main purpose of React is to be fast, scalable, and simple. It works only on user interfaces in the

application. This corresponds to the view in the MVC template. It can be used with a combination of other JavaScript libraries or frameworks, such as Angular JS in MVC.

React.js properties include the following:

• React.js is declarative
• React.js is simple
• React.js is component based
• React.js supports server side
• React.js is extensive
• React.js is fast
• React.js is easy to learn

Flux Architecture
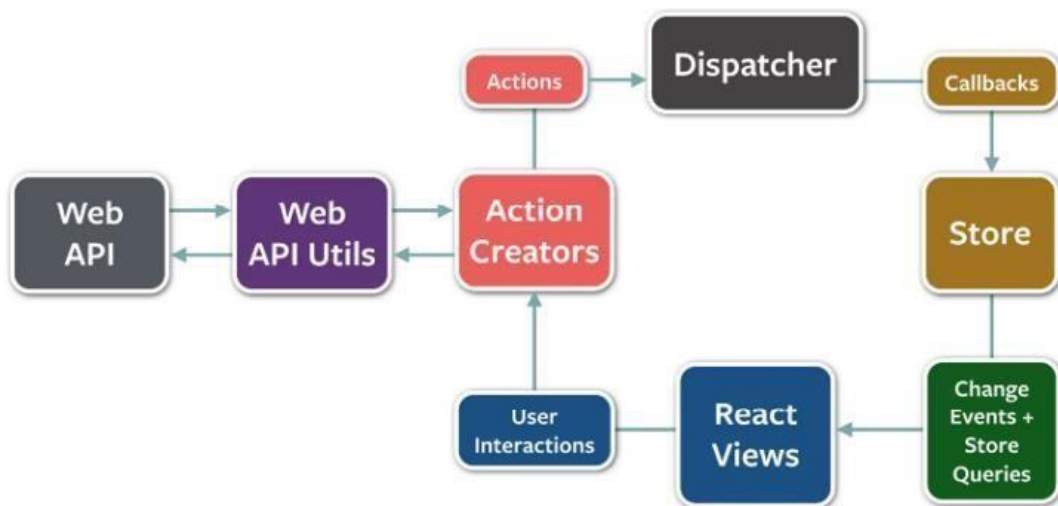
After learning a few highlights regarding the instability and complexity of the MVC architecture, the Facebook development team made some important changes in the system and released Flux as an alternative to MVC architecture. The Flux architecture is based on the following components:

• Store/ Stores: Serves as a container for the app state & logic
• Action: Enables data passing to the dispatcher

• View: Same as the view in MVC architecture, but in the context of React components

• Dispatcher – Coordinates actions & updates to stores

Application Modules

We propose a layered architecture to achieve transparency and immutability of the stored records on the blockchain network. The advantages of the proposed architecture include modularity, maintainability, flexibility, scalability.

• API: REST Application Programming Interface exposing the features of the proposed blockchain application to other applications with a high level of abstraction.

• Controller: This component is responsible for querying and manipulating the data stored on blockchain into high-level information for the client application.

• Blockchain: The main component of the application having all the business logic implemented through smart contracts on the blockchain.

The various stakeholders involved in the food supply chain are:

1. Farmer: Responsible for making the land for harvesting the crops, sowing the seeds and taking care of it.

2. Manufacturer: Produces finished goods from raw materials.

3. Distributor: Responsible for moving the finished goods from manufacturer to retailer.

4. Retailer: Responsible for selling the products directly to consumers.

5. Consumer: Responsible for purchasing the goods.

System Stakeholders: -

Blockchain Technology

1)Farmer   2)Manufacturer   3)Distributer   4)Retailer   5)Consumer
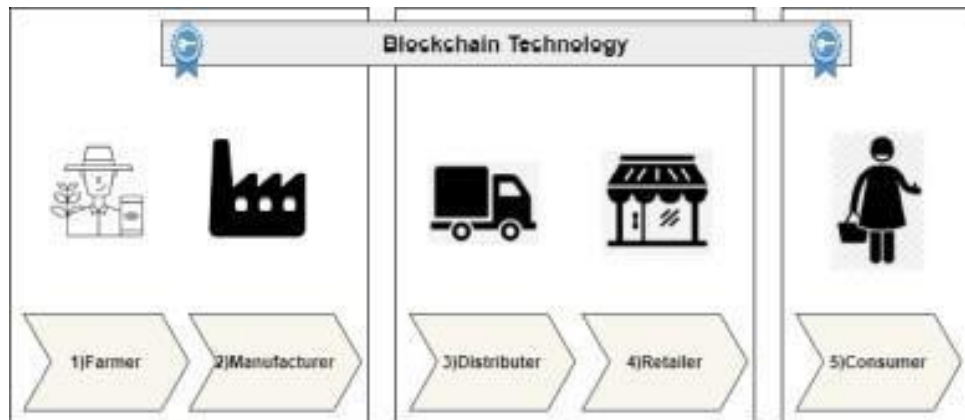
CHAPTER-5

Result and Conclusion

In this section, we begin by introducing the existing supply chain system and proposing a blockchain-based food supply chain system.

• Food Supply Chain Overview

The food supply chain system describes the process of how food items are processed and supplied to end-users. The journey includes production, distribution and consumption. Then material we consume reaches us using a food supply chain where items move in domino-like motion from manufacturers to customers. As the supply chain is domino-like were affecting one part of the supply chain can affect the whole supply chain. In fact, governments and organizations have taken note of food security issues and have taken steps to address them. However, there is a long way to go.

• Flaws in Centralized System

Lack of traceability, growing regulations, rising supply chain costs, consumer trust, product quality, environmental impact, etc are the reliability issues that are faced in the current food supply chain. Consumers demand more transparency and information but current systems are not capable of providing such information. In most cases, the information is checked by third parties, and the records are kept on paper or in the centralized database.

• Food Supply System using Blockchain

Blockchain helps to improve traceability in the food supply chain by providing a decentralized public ledger that helps to connect farmers, manufacturers, distributors and consumers who are far apart and working under different geographical conditions. Transactions in the blockchain cannot be altered as every change is reflected in the entire network. Through the use of the Blockchain-based platform, features like smart contracts, decentralized databases, and proof of performance ensure security and transparency in the food supply chain.

Therefore, our blockchain-based food tracking system is based on the Ethereum blockchain, which is an open-source and smart contract application. The reason we use this blockchain is that it provides a structured and flexible

design, which is scalable and authentic. Alternatively, it can be structured as a federated blockchain that is reliable and trustworthy between different groups and is suitable for supply management applications.

In this paper, a blockchain-based solution has been proposed which facilitates a secure and authorized flow of food items throughout the supply chain and security to the stored data that is encrypted, decentralized and cross-checked which permit the data to remain strongly backed. The system also allows tracking the product ownership transaction history from manufacturing to consumers.

CHAPTER-6

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