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BLOCKCHAIN BASED SOLUTION TO IMPROVE THE SUPPLY CHAIN MANAGEMENT IN INDIAN AGRICULTURE

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ABSTRACT

India stands as a prominent agricultural hub globally, with its agricultural roots tracing back to the Indus Valley Civilization. Despite its rich agricultural history, many Indian farmers struggle to secure adequate income, while foreign nations reap substantial profits from similar produce. A significant contributing factor to this disparity is the glaring inadequacy in the country's supply chain management. The perishable nature of agricultural products exacerbates the issue, as improper maintenance often leads to rapid decay. Although the government provides storage facilities, the existing supply chain lacks effective monitoring mechanisms. Farmers grapple with the inability to track the status of their produce, and the transportation process lacks systematic checkpoints. Consequently, there is an urgent call for an enhanced supply chain management system that incorporates essential features like comprehensive checkpoints at each stage and verification of goods status by both farmers and government officials. This project proposes a solution leveraging Block chain technology to introduce transparency in monitoring goods' status, fostering a more robust relationship between producers and consumers. By employing Block chain, the system ensures visibility of the entire process to both farmers and transportation officials. Moreover, the immutable records maintained within the Block chain guarantee the preservation of information indefinitely.

Keywords: Agriculture, Supply Chain, Block Chain, Track, Transactions, IOT, Sensors Etc.

I. INTRODUCTION

India, with its agrarian roots, heavily relies on agriculture, which contributes about 18% to its economy. However, the plight of Indian farmers is dire, especially those engaged in small-scale farming, constituting roughly 80% of the agricultural workforce, with landholdings of two hectares or less. Their livelihoods hinge on the crops they cultivate, but unpredictable climatic conditions, characterized by either devastating floods or prolonged droughts, often thwart their efforts. Additionally, the perishable nature of their produce coupled with inadequate storage facilities deprives them of fair prices, leaving many struggling to meet their basic needs. Furthermore, the absence of a fair pricing mechanism exacerbates their financial woes.

Amidst these challenges, blockchain technology emerges as a promising solution, originally stemming from Bitcoin. It operates as a decentralized ledger system facilitating transparent transactions among farmers, agents, and consumers. By structuring data into blocks and validating transactions through consensus among all parties, blockchain ensures the integrity of recorded information. The Ethereum Virtual Machine (EVM) further enhances its capabilities by executing smart contracts, which automate agreements based on predefined conditions. Powered by Proof of Work (PoW), miners validate transactions, bolstering the security of blockchain networks. Integrating blockchain with the Internet of Things (IoT) in agriculture holds tremendous potential to revolutionize the sector, despite facing implementation hurdles.

Problem Statement:

A myriad of challenges plague agricultural and food supply chains, ranging from traceability and transparency issues to inefficiencies. These obstacles impede efforts to enforce compliance, ensure food safety and quality, minimize waste, and optimize operational costs. As demand for agricultural products surges unexpectedly, traditional supply chains must evolve to meet these demands. Moreover, effective supply chain management is instrumental in enhancing customer satisfaction by facilitating seamless product flow, information management, and tracking product provenance. However, conventional centralized systems lack traceability, transparency, and are susceptible to data manipulation and security breaches. The current system fails to address the following key issues:

1. Lack of traceability and transparency.
2. Absence of product origin information.
3. Inadequate assurance of food safety at every stage.
4. Absence of transaction records across the entire supply chain.

Project Motivation:

1. **Addressing Persistent Challenges:** The integration of blockchain technology in agricultural supply chains is driven by the pressing need to tackle long-standing issues such as traceability, transparency, and inefficiencies.
2. **Leveraging Decentralization:** By leveraging blockchain's decentralized nature, the project aims to foster greater trust among stakeholders involved in the agricultural supply chain.
3. **Enhancing Traceability:** Blockchain technology offers a transparent ledger system that enables seamless traceability of agricultural products from farm to consumer. This can significantly improve accountability and reduce the risk of fraudulent activities within the supply chain.
4. **Reducing Fraud:** Through the immutability of blockchain records, the project seeks to reduce instances of fraud within agricultural supply chains. The transparent and tamper-proof nature of blockchain transactions can help prevent unauthorized alterations to data.
5. **Eliminating Intermediaries:** By cutting out intermediaries, blockchain technology has the potential to streamline the agricultural supply chain, reducing transaction costs and improving efficiency.
6. **Optimizing Product Quality:** With blockchain-enabled traceability, farmers and consumers can access detailed information about the origin and journey of agricultural products. This transparency can lead to higher-quality products reaching the market.
7. **Ensuring Food Safety:** Blockchain's ability to provide an immutable record of each transaction in the supply chain can enhance food safety measures. It allows for the rapid identification of sources of contamination and facilitates timely recalls if necessary.
8. **Empowering Stakeholders:** Through blockchain technology, stakeholders in the agricultural supply chain, including farmers, distributors, and consumers, can have greater control over their transactions and access to information.
9. **Encouraging Innovation:** The integration of blockchain in agriculture encourages innovation and the adoption of cutting-edge technology in traditionally conservative sectors. This can lead to the development of new solutions and business models that benefit all participants in the supply chain.
10. **Meeting Market Demands:** As consumer demand for transparency and sustainability grows, blockchain technology can help agricultural businesses meet these expectations by providing verifiable information about the production and sourcing of their products.

Objectives of the Project:

1. Implementation of Blockchain-Based Tracking System:

The primary objective of the project is to implement a blockchain-based system to track and trace agricultural products throughout the supply chain. This system will ensure transparency and accountability at every stage of production, processing, and distribution.

2. Establishment of a Transparent Ecosystem:

Another objective is to establish a transparent ecosystem by leveraging blockchain's immutable ledger. This will enable farmers, suppliers, distributors, and consumers to access authenticated information about the origin, quality, and handling procedures of agricultural products.

3. Streamlining Supply Chain Processes:

The project aims to streamline supply chain processes by eliminating unnecessary intermediaries through the use of smart contracts. This will facilitate direct transactions between farmers and consumers, thereby reducing costs and improving profit margins for farmers.

4. **Promotion of Fair Trade Practices:**

To foster fair trade practices, the project will utilize blockchain technology to certify fair compensation for farmers. This ensures equitable payment and recognition for their produce based on predetermined conditions, promoting fairness and sustainability in the agricultural industry.

5. **Real-Time Monitoring of Product Quality:**

Lastly, the project will deploy blockchain technology to enable real-time monitoring of product quality, storage conditions, and transportation. This ensures that consumers receive high-quality, safe, and fresh agricultural products, enhancing consumer trust and satisfaction.

II. METHODOLOGY

The proposed methodology for implementing the project involves the integration of blockchain technology and IoT devices to create a secure and transparent agricultural supply chain system. The process flow and step-by-step approach are detailed below:

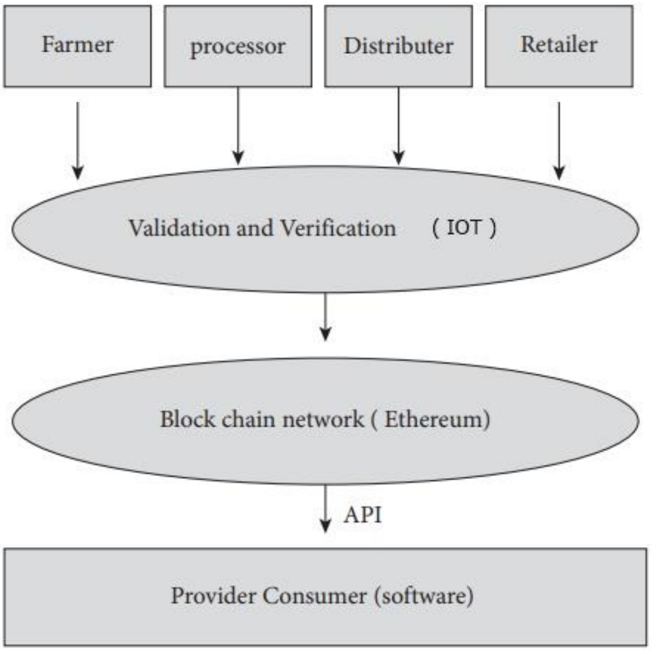

Figure 1: Architecture Diagram

1. **Requirement Analysis:**
- ➢ Conduct a comprehensive analysis to identify the specific requirements and challenges of the agricultural supply chain.
- ➢ Define the objectives and scope of the project, considering factors such as transparency, traceability, and efficiency improvement.

2. **Designing the Blockchain Framework:**
- ➢ Develop a robust blockchain framework tailored to the needs of the agricultural supply chain.
- ➢ Design the architecture, data structure, and consensus mechanism for the blockchain network.

3. **IoT Integration:**
- ➢ Integrate IoT devices such as sensors (temperature, humidity, gas) into the supply chain infrastructure.
- ➢ Ensure seamless communication between IoT devices and the blockchain network for real-time data transmission.

4. **Data Collection and Transmission:**
- ➢ Collect relevant data from farms, transportation vehicles, and storage facilities using IoT sensors.
- ➢ Transmit the collected data securely to the blockchain network for storage and verification.

5. **Smart Contract Implementation:**
- ➢ Develop and deploy smart contracts using Solidity programming language to automate and enforce business rules.

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- Define conditions and validation rules within smart contracts to ensure the accuracy and integrity of transactions.

6. **Testing and Validation:**

- Conduct rigorous testing of the blockchain system and IoT devices to validate functionality, reliability, and security.
- Verify the accuracy of data transmission, smart contract execution, and integration with external systems.

7. **Pilot Implementation:**

- Implement the blockchain-based supply chain system on a small scale to evaluate its performance in a real-world environment.
- Gather feedback from stakeholders and identify areas for improvement based on pilot results.

8. **Scalability and Deployment:**

- Scale up the implementation to cover larger agricultural networks and accommodate increased transaction volumes.
- Deploy the finalized system across the entire agricultural supply chain, ensuring seamless integration and operation.

9. **Continuous Monitoring and Improvement:**

- Establish mechanisms for continuous monitoring and evaluation of the blockchain system's performance.
- Incorporate feedback from users and stakeholders to make iterative improvements and enhancements.

This methodology aims to leverage the synergies between blockchain and IoT technologies to address challenges, enhance transparency, traceability, and efficiency in the agricultural supply chain. By following a systematic approach, the project endeavors to optimize agricultural processes and foster sustainable practices in the industry.

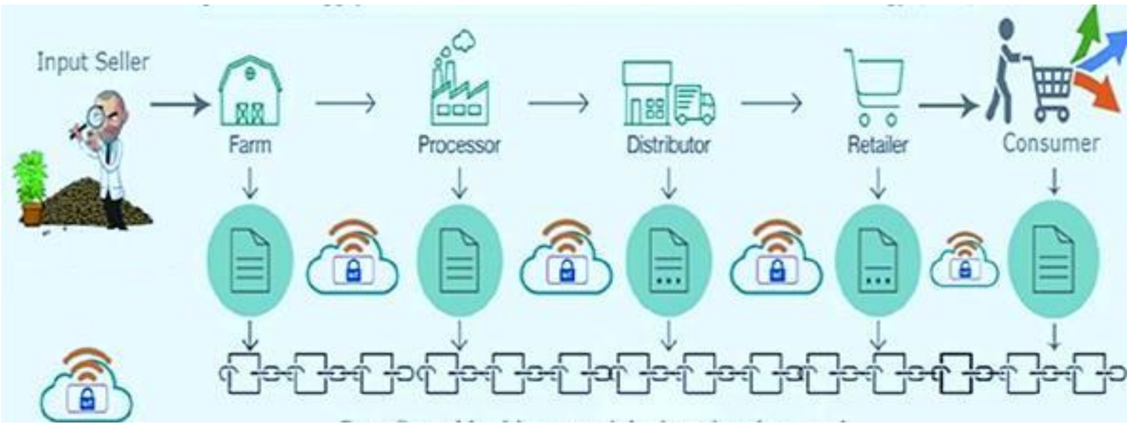

Figure 2: Process Flow

III. HARDWARE AND SOFTWARE UTILIZED

Hardware Utilized:

- 8 GB RAM (16 GB recommended): The system requires a minimum of 8GB RAM, with 16 GB recommended for optimal performance.
- Core i5 Processor: A system with at least a Core i5 processor is recommended.
- Node MCU Development Board (ESP8266): The Node MCU Development Board, specifically the ESP8266 microcontroller, serves as a key component in the hardware setup. It features built-in Wi-Fi capability and a variety of pins for connectivity.
- **Specifications:**
  - Voltage: 3.3V
  - Wi-Fi Direct (P2P), soft-AP
  - Current consumption: 10uA~170mA
  - Flash memory attachable: Up to 16MB (512K normal)
  - Integrated TCP/IP protocol stack
  - Processor: Tensilica L106 32-bit

- Processor speed: 80~160MHz
- RAM: 32K + 80K
- GPIOs: 17 (multiplexed with other functions)
- Analog to Digital: 1 input with 1024 step resolution
- Output power in 802.11b mode: +19.5dBm
- 802.11 support: b/g/n
- Maximum concurrent TCP connections: 5

➢ Gas Sensor (MQ135): Utilized for detecting and alerting harmful gases during the transportation of crop produce.

➢ DHT11 Temperature and Humidity Sensor: Measures relative humidity and temperature to ensure optimal conditions for the transported goods.

➢ **Push Button:** Used for data transmission of temperature, humidity, and bus data to the cloud.

Software Utilized:

➢ **Python:** The entire project is programmed using Python, an interpreted, high-level programming language known for its simplicity and versatility.

➢ **Anaconda Navigator:** A desktop graphical user interface included in Anaconda distribution for managing conda packages, environments, and channels.

➢ **Private Ethereum Network:** A blockchain network composed of multiple Ethereum nodes, configured to run locally and communicate with each other.

➢ **JavaScript:** Utilized for creating dynamic and interactive elements on websites and handling asynchronous communication with servers.

➢ **Truffle:** A development framework for Ethereum, facilitating smart contract development, deployment, and testing.

➢ **Blockchain API:** Provides developers with functionality to interact with a blockchain network, enabling operations such as retrieving data and submitting transactions.

➢ **Arduino IDE:** An open-source electronics platform used for programming microcontrollers and developing embedded systems.

➢ **Brackets IDE:** A lightweight yet powerful text editor for web development, offering visual tools and GitHub integration.

➢ **WAMP Server:** A web development environment consisting of Apache, MySQL, and PHP, facilitating local development of web applications.

➢ **EasyEDA:** A web-based Electronic Design Automation tool for creating circuit schematics, designing PCBs, and simulating electronics circuits.

➢ **Android Studio:** The official Integrated Development Environment (IDE) for Android app development, providing features like code editing, debugging, and testing.

1. Project Structure

1. Modules in Android Studio:

➢ Android Studio projects comprise modules containing source and resource files.

➢ Types of modules:

- Android app modules
- Library modules
- Google App Engine modules

➢ By default, project files are displayed in the Android project view, organized by modules for easy access to key source files.

2. Module Structure:

➢ Build files are visible under Gradle Scripts.

➢ Each app module includes the following folders:

- manifests: Contains AndroidManifest.xml file.
- java: Contains Java source code files, including JUnit test code.

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- res: Holds non-code resources like XML layouts, UI strings, and bitmap images.

3. Actual File Structure:

- The actual file structure on disk differs from the flattened representation.
- To view the true file structure, select Project from the Project dropdown.

4. Customizing Project View:

- Customize the view to focus on specific aspects of app development.
- For example, the Problems view displays links to files containing recognized coding and syntax errors.

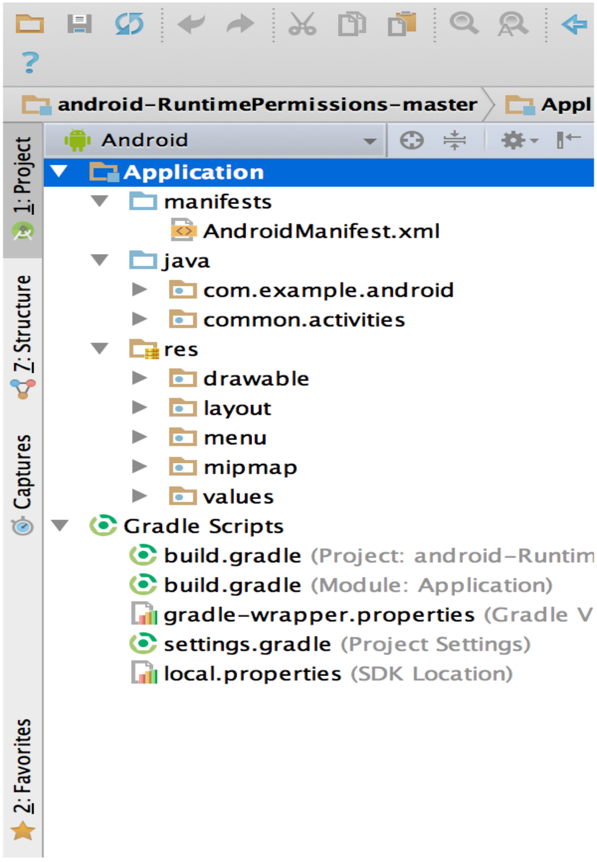

Figure 3: The project files in Android view.

User Interface

1. Toolbar:

- Enables various actions, such as running the app and launching Android tools.

2. Navigation Bar:

- Aids in project navigation and file opening.
- Offers a compact view of the Project window structure.

3. Editor Window:

- Used for code creation and modification.
- Adjusts based on the file type being viewed (e.g., Layout Editor for layout files).
- Tool Window Bar:
- Surrounds the IDE window and contains buttons to expand or collapse individual tool windows.

4. Tool Windows:

- Provide access to specific tasks like project management, search, and version control.
- Can be expanded or collapsed based on needs.

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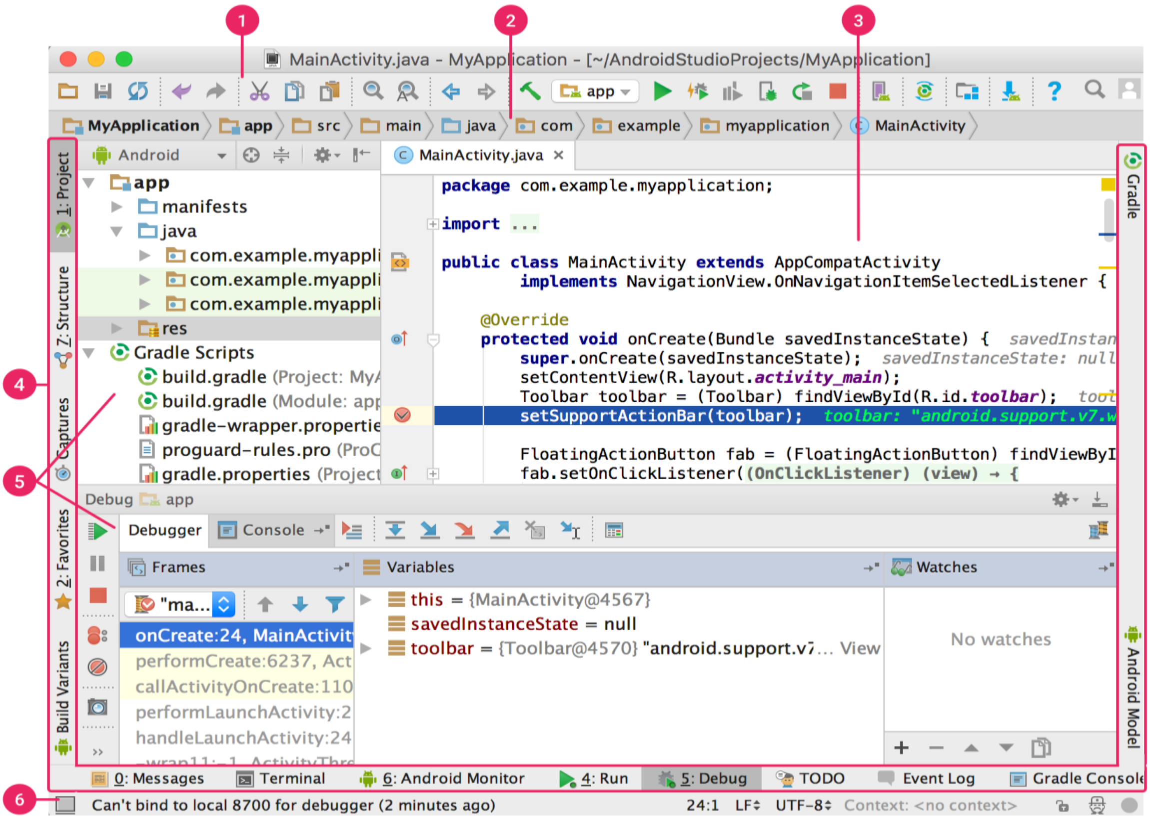

Figure 4: User Interface

IV. FUNCTIONAL AND NON-FUNCTIONAL REQUIREMENTS

Functional Requirements:

The implementation of the Music and Video recommendation system based on facial mood detection is divided into several modules:

1. Facial Mood Recognition System Development:

- This module involves training a deep learning-based facial recognition model to detect expressions and moods (e.g., happiness, sadness).
- Steps include dataset collection, data augmentation, batch normalization, and performance analysis of the trained emotion recognition model.

2. Music and Video Recommendation System Development:

- This module suggests relevant music and videos based on the output of the emotion recognition model.
- The system selects content from a customized playlist using Python backend.

3. Flask-based Recommendation Application:

- This module develops a web application using Flask backend to generate recommendations based on detected emotions.
- The application captures images using the webcam, detects emotions, and displays music and video recommendations on the frontend.

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Use Case Diagram:

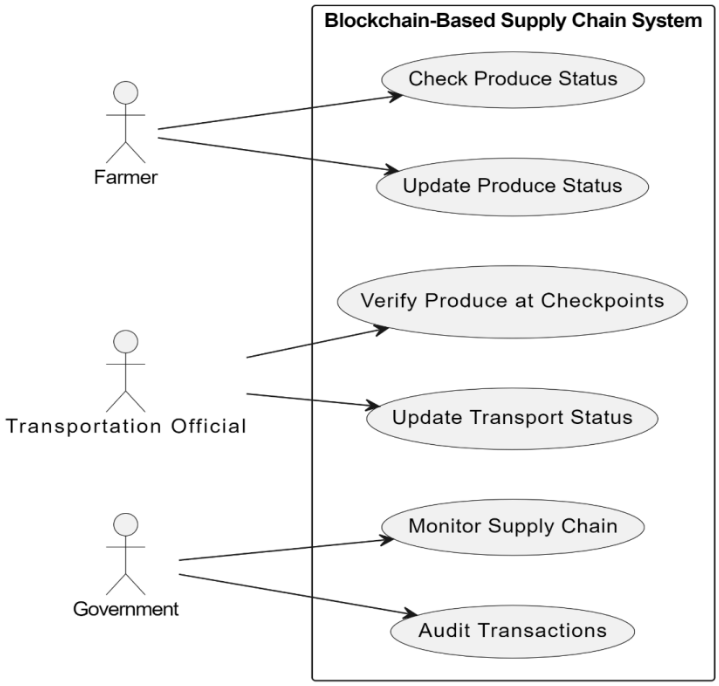

Figure 5: Use Case Diagram

Use Case 1: Check Produce Status

- Primary Actor: Farmer
- Goal: View the current status of produce in the supply chain.
- Stakeholders: Farmer, Government
- Main Success Scenario: Farmer logs in, selects produce batch, system displays status.

Use Case 2: Update Produce Status

- Primary Actor: Farmer
- Goal: Update produce status in the supply chain.
- Stakeholders: Farmer, Government
- Main Success Scenario: Farmer updates status, system verifies and records on blockchain.

Use Case 3: Verify Produce at Checkpoints

- Primary Actor: Transportation Official
- Goal: Verify and update produce status at checkpoints.
- Stakeholders: Transportation Official, Farmer
- Main Success Scenario: Official scans produce, updates status, system records on blockchain.

Use Case 4: Monitor Supply Chain

- Primary Actor: Government/Backend App
- Goal: Monitor overall health and integrity of the supply chain.
- Stakeholders: Government, Farmers, Transportation Officials
- Main Success Scenario: Government official accesses dashboard, reviews data, system provides notifications.

Non-Functional Requirements:

- **Performance:** Ensure secure transactions.
- **Scalability:** System should be scalable for future commercialization and data expansion.
- **Maintainability:** Maintenance should not be an issue as the project is in software form.
- **Usability:** System should be easy to use.
- **Reliability:** System should be reliable and accurate, with minimum false positives.
- **Security Issues**: Security is not a requirement for this project.

V. SYSTEM IMPLEMENTATION

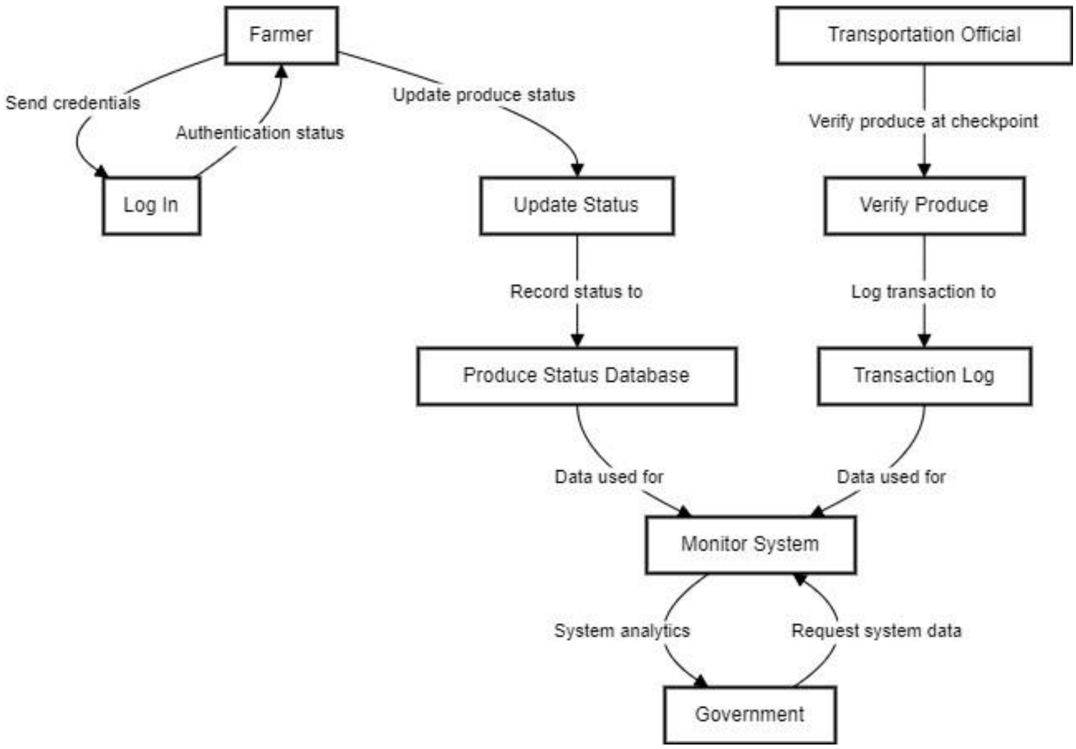

Figure 6: Data Flow Diagram

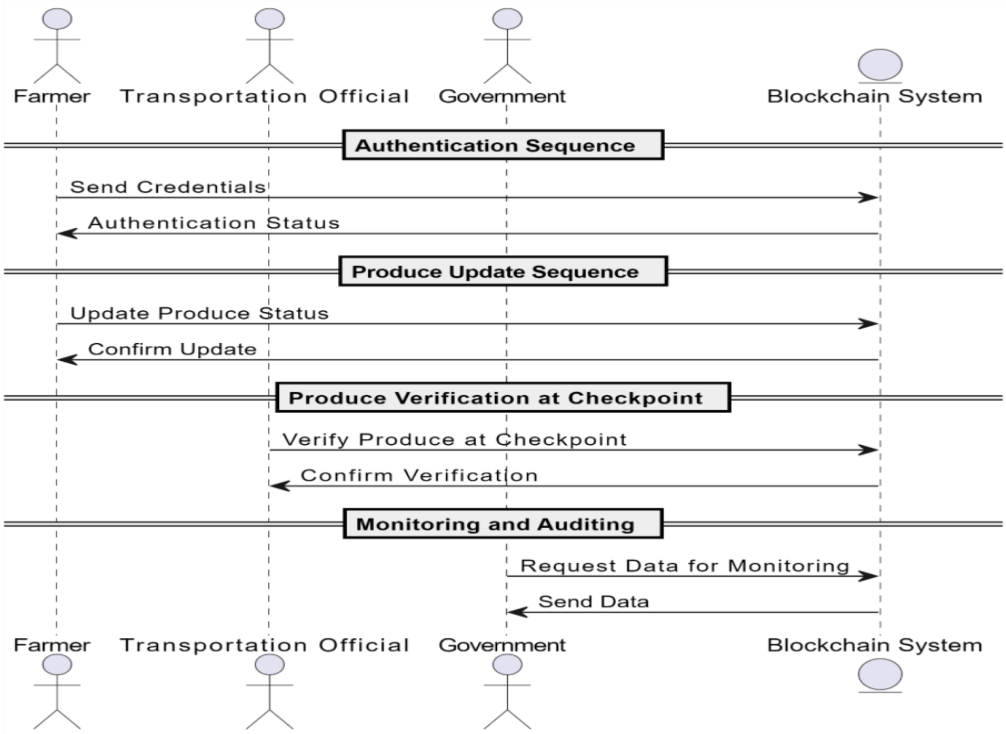

Figure 7: Sequence Diagram

Blockchain System:

- The system involves authentication, produce status updates, verification at checkpoints, and monitoring by the government, all facilitated by blockchain technology.
- Blockchain ensures transparency and traceability in the supply chain.

Hardware Implementation:

- **Types of Circuit Boards:** Single-Sided, Double-Sided, Multi-Layer
- **Parts of PCB:** Substrate, Copper Layer, Solder Mask, Silk Screen
- **Schematic Development:** Schematic circuit diagram developed using EasyEDA.
- **Smart Sensor Hub Hardware:** Development of hardware for temperature and humidity logging using IoT and blockchain.
- **Assembled Smart Sensor Node:** Hardware unit with sensor nodes and GPS for location logging.
- **Software Implementation:** IoT communication protocols implemented for data transmission from hardware.

Software Implementation:

- **Android Applications:** Developed for data input and communication with the network.
- **Backend Blockchain System:** Network created in Ganache, smart contract created and deployed using Solidity and Web3 API.

VI. CONCLUSION

1. Introduction of a Blockchain-based System:

The project introduces a novel system integrating blockchain with IoT to monitor agricultural goods' status.

2. Enhanced Visibility:

By storing updates in blockchain, all supply chain intermediaries gain visibility into goods' location and delivery timelines.

3. Transparency and Accessibility:

Blockchain records, being immutable, ensure transparency and accessibility of documents for SCM participants.

4. Potential for Future Expansion:

Despite initial investment requirements, the project holds promise for expansion into other sectors, facilitated by either farmers or government intervention.

5. Benefits for Farmers:

Adoption of modern technologies in agriculture can ultimately enhance farmers' livelihoods.

VII. FUTURE SCOPE

1. Expansive Potential:

The future scope of the project extends to sectors beyond agriculture, including pharmaceuticals, manufacturing, and logistics.

2. Integration of Advanced Technologies:

Integration of advanced analytics, artificial intelligence, and IoT devices could enhance system efficiency, accuracy, and real-time monitoring capabilities.

3. Deeper Insights:

These integrations offer deeper insights into supply chain dynamics, predictive maintenance, and automated decision-making processes.

4. Expansion of Blockchain Network:

Expanding the blockchain network to include more stakeholders such as retailers and consumers could foster greater transparency and trust across the entire supply chain.

5. Improved Compliance and Sustainability:

Greater transparency and trust could lead to better compliance with regulatory standards and improved sustainability practices.

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