SYNOPSIS

1. INTRODUCTION

1.1 Project Overview.

This food traceability system introduces a straightforward and efficient traceability technology designed specifically for vegetables and fruits. It aims to provide basic traceability capabilities to enhance transparency and safety in the fresh product supply chain. A food traceability system utilizing blockchain technology is a sophisticated and innovative approach to ensuring the transparency, authenticity, and products throughout the supply chain. This system leverages the inherent features of blockchain, such as decentralization, immutability, and transparency, to create an unalterable digital ledger that records every step of a food product's journey from farm to table.

Blockchain technology, originally designed for crypto currencies like Bit coin, has found numerous applications beyond finance. One of the most promising areas is supply chain management, particularly in the food industry. Food traceability is crucial for consumers who want to know where their food comes from and for businesses looking to ensure the safety and quality of their products. The core of this system is a decentralized ledger, or blockchain, which consists of a chain of blocks, each containing a list of transactions or events. In the context of food traceability, these transactions represent various activities and data points along the supply chain. Ethereum is a popular blockchain platform known for its smart contract capabilities. It provides a decentralized, tamper-proof ledger that's ideal for implementing a food traceability system. Each participant in the system interacts with the Ethereum blockchain through their own Ethereum address, which can hold crypto currency (Ether) and execute smart contracts. Smart contracts are self-executing contracts with predefined rules and conditions.

1.2 Purpose

Consumer and retailers can access the information by scanning the QR code or barcode using a smart phone or web-based interface. They can quickly learn where the product was brought from, when it was harvested, and any relevant safety certifications it holds.

Every stakeholder in the food supply chain that needs access to the data can create a unique digital ID called a decentralized identifier (DID) that can be stored on the blockchain.

Each party can add food data to product DIDs in the form of Verifiable Credentials which will help track food products.

For each product or batch is given its own identification number, which enables an internal company and plant track & trace.

This identification number can be assigned additional information throughout the manufacturing process, such as dimensions or inspection results.

One of the tools used for assuring quality and safety in the entire food supply chain is providing reliable information through traceability.

A well-developed traceability system allows food businesses, to have access to absolute transparency about the product by providing requisite information at each step of the supply chain.

Traceability has been universally employed as a risk management tool to arrest the supply of unsafe food in the supply chain by permitting withdrawal or recall of food products by the manufacturers as well as the regulators.

This system offers several advantages, including immutable data storage, decentralized control and enhanced transparency. We here by mention the data storage and access, smart contract, user interfaces.

2. LITERATURE SURVEY

2.1 Existing Problem

The current food tracing system faces several challenges. One major problem is the lack of transparency and real-time tracking. Consumers often don't have access to detailed information about the origin, quality, and safety of the food they buy. This lack of transparency makes it difficult to ensure the integrity of the supply chain and track the food's journey from farm to table. Another issue is the reliance on manual record-keeping, which is prone to errors and delays. This can lead to inaccurate or outdated information, making it harder to effectively trace and recall products in case of contamination or other safety concerns. To overcome these challenges, a blockchain-based food tracing system could be implemented. Blockchain technology provides a decentralized and tamper-proof digital ledger, which securely records every step of the food supply chain. This enables real-time tracking, transparent record-keeping, and seamless traceability. By leveraging blockchain, consumers would have access to reliable and up-to-date information about the origin, production practices, handling, and distribution of the food they consume. This empowers them to make informed decisions and encourages accountability among food producers and suppliers. Overall, implementing a blockchain-based food tracing system would enhance transparency, improve food safety, and strengthen consumer trust in the food supply chain. It's a promising solution that can revolutionize the way we track and trace our food, ensuring its quality, safety, and sustainability.

2.2 References

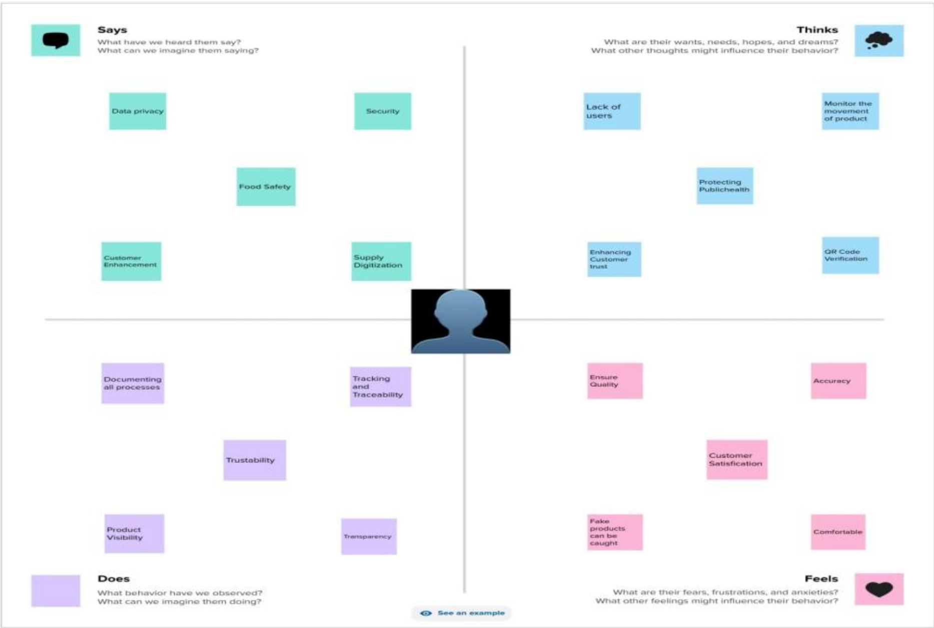
1. Y.-P. Lin et al., “Blockchain: The Evolutionary Next Step for ICT E-Agriculture,” Environments, vol. 4, no. 3, Art. no. 3, Sep. 2017.
2. Y. Liao and K. Xu, “Traceability System of Agricultural Product Based on Block-chain and Application in Tea Quality Safety Management,” J. Phys. Conf. Ser., vol. 1288, p. 012062, Aug. 2019.
3. J. Lin, Z. Shen, A. Zhang, and Y. Chai, “Blockchain and IoT based Food Traceability for Smart Agriculture,” in Proceedings of the 3rd International Conference on Crowd Science and Engineering, Singapore, Singapore, Jul. 2018, pp. 1–6.
4. Y. Wang, K. Chen, M. Hao, and B. Yang, “Food Safety Traceability Method Based on Blockchain Technology,” J. Phys. Conf. Ser., vol. 1634, p. 012025, Sep. 2020.
5. K. Biswas, V. Muthukumarasamy, and W. Lum, “Blockchain Based Wine Supply Chain Traceability System,” Nov. 2017.
6. I.-C. Lin, H. Shih, J.-C. Liu, and Y.-X. Jie, “FOOD TRACEABILITY SYSTEM USING BLOCKCHAIN,” p. 6, 2017.
7. D. Bumbass's, A. Mann, B. Dugan, and J. Rittmer, “A blockchain use case in food distribution: Do you know where your food has been?” Int. J. Inf. Manag., vol. 52, p. 102008, Jun. 2020.
8. N. Mishra, S. Mistry, S. Choudhary, S. Kudu, and R. Mishra, “Food Traceability System Using Blockchain and QR Code,” 2020, pp. 33–43.
9. G. Barella, S. Iba, M. Marchesi, R. Tonelli, and S. Messineo, “A Blockchain Based System to Ensure Transparency and Reliability in Food Supply Chain: Euro-Par 2018 International Workshops, Turin, Italy, August 27-28, 2018, Revised Selected Papers,” 2019, pp. 379–391.

2.3 Problem Statement Definition

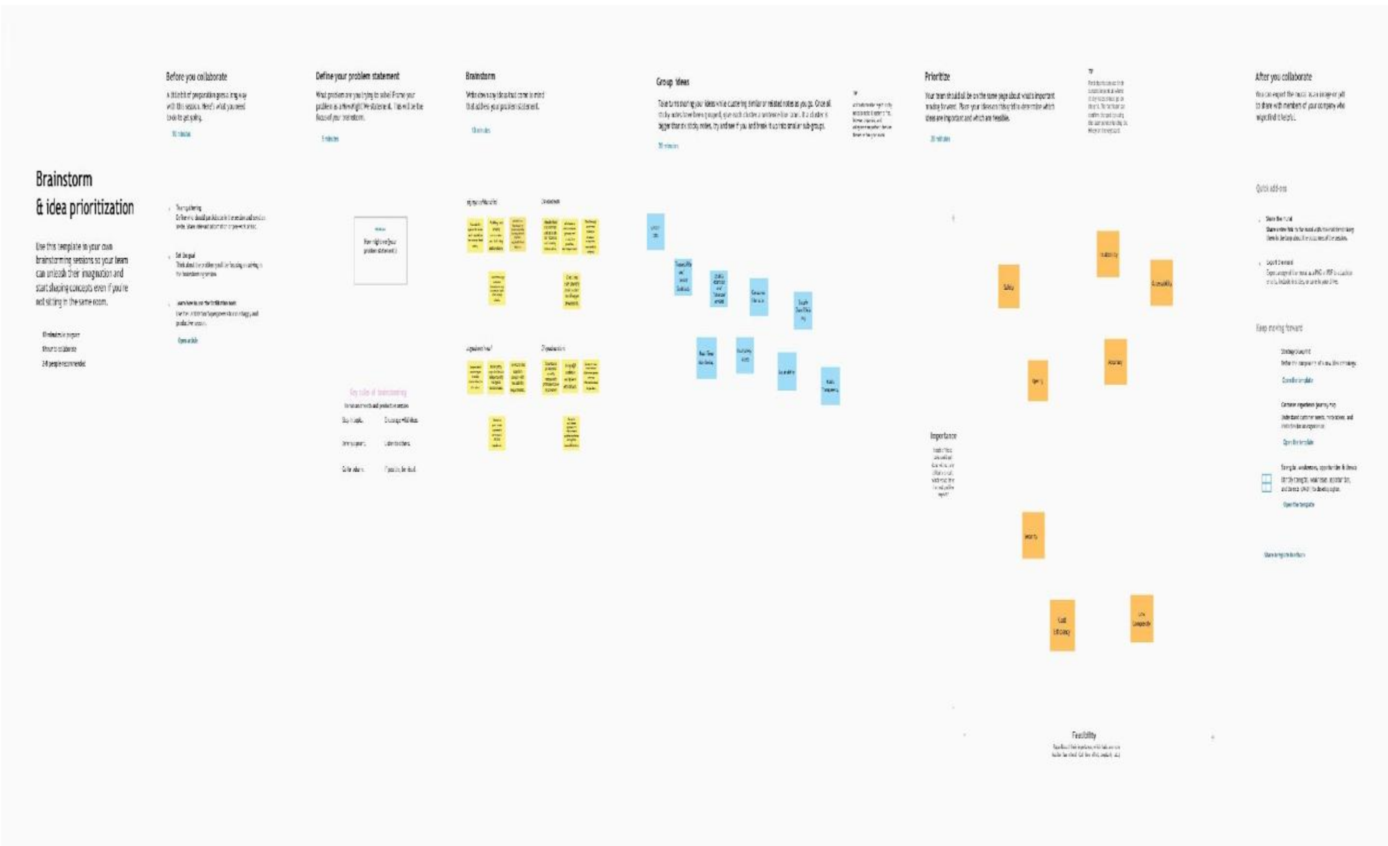
The current food supply chain suffers from a lack of transparency and inefficiencies, making it difficult to ensure the quality and safety of the food we consume. Information about the origin, production, and transportation of food is often limited, leading to challenges in effectively tracing and detecting the source of contamination or foodborne illnesses. Additionally, the complexity of global supply chains makes it difficult to address issues such as fraud, mislabelling, and counterfeit products. These challenges undermine consumer trust, compromise food safety, and hinder sustainable development in the food industry. Therefore, there is a critical need to implement blockchain technology for food traceability to enhance transparency, improve food safety, protect public health, and promote a resilient and sustainable food supply chain.

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas



3.2 Ideation & Brainstorming



4. REQUIREMENT ANALYSIS

4.1 Functional Requirements

1. Data Capture and Recording: The system should be able to capture and record relevant data at each stage of the food supply chain, such as production, processing, packaging, and transportation.

2. Transparency and Accessibility: The traced food data should be easily accessible to consumers, producers, regulators, and other stakeholders, promoting transparency and accountability.

3. Real-time Tracking: The system should enable real-time tracking of food products, allowing stakeholders to monitor their movement and status throughout the supply chain.

4. Traceability and Product Identification: The solution should provide unique identifiers for each food product, enabling easy traceability and identification in case of recalls or safety concerns.

5. Verification and Authentication: The system should incorporate mechanisms to verify the authenticity and integrity of traced data and ensure that it cannot be altered or tampered with.

6. Integration with Existing Systems: The solution should have the ability to integrate with existing databases, information systems, and technologies already used in the food industry for streamlined data sharing and interoperability.

7. Reporting and Analytics: The system should generate meaningful reports and analytics based on the traced data, providing valuable insights for decision-making and identifying areas for improvement.

4.2 Non-functional Requirements

1. Scalability: The system should be able to handle a large volume of transactions and data as the food supply chain grows, ensuring smooth performance and responsiveness.

2. Security: The blockchain-based solution should prioritise data security and privacy, implementing robust encryption and access control mechanisms to protect sensitive information.

3. Reliability: The system should be always reliable and available, minimising downtime and ensuring continuous access to traced food data.

4. Usability: The user interface of the system should be intuitive and easy to use, requiring minimal training or technical knowledge for stakeholders to navigate and understand the traced information.

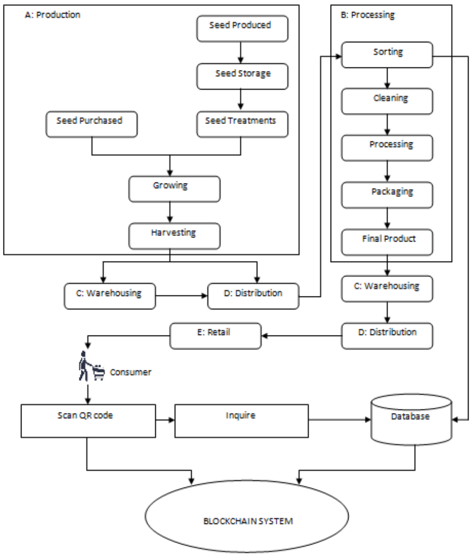
5. Interoperability: The solution should be compatible with different platforms, systems, and technologies used by stakeholders in the food industry, enabling seamless integration and data sharing.

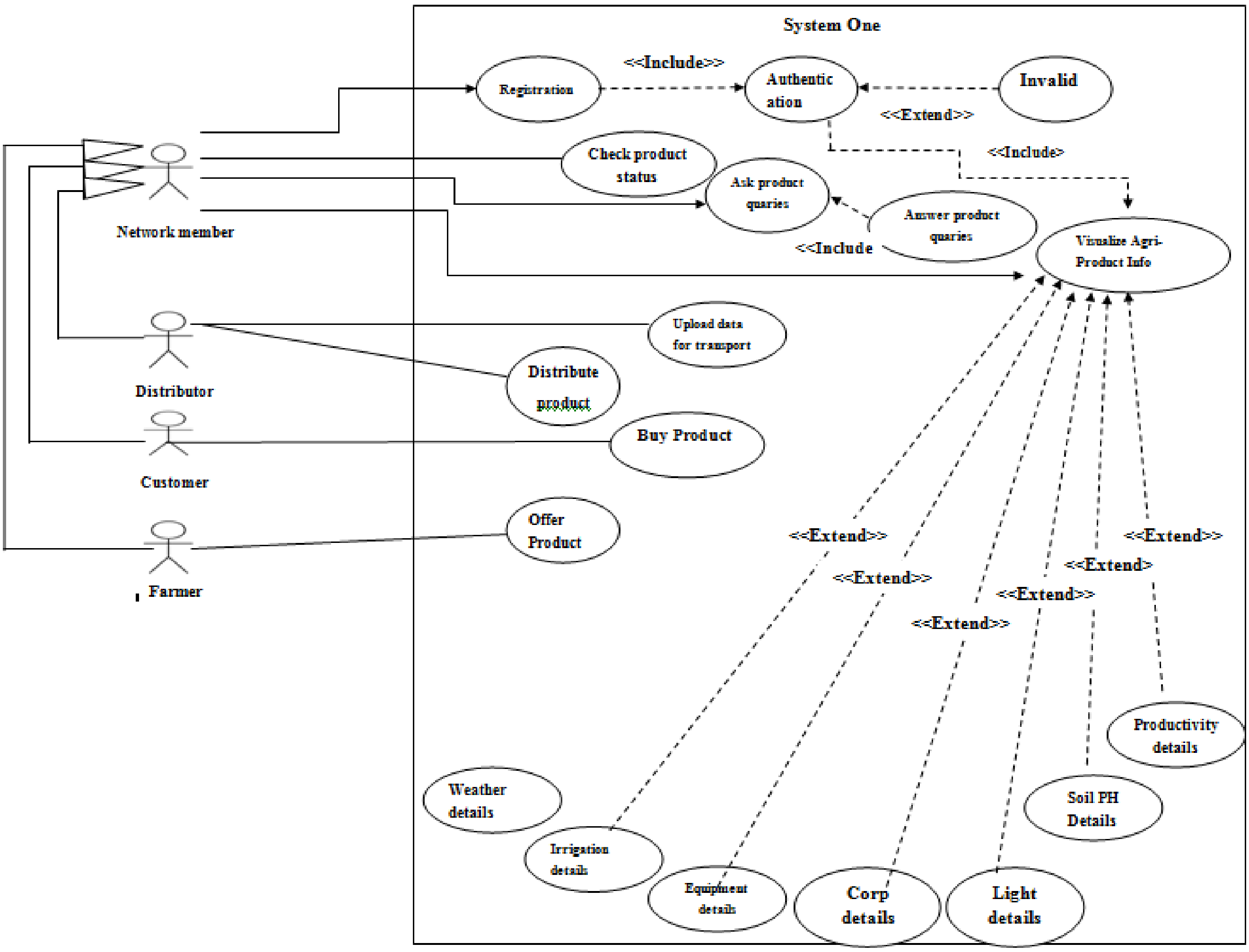
6. Compliance: The system should adhere to relevant regulatory requirements and standards for food traceability, ensuring compliance with food safety regulations and guidelines.

7. Performance: The system should perform efficiently and deliver fast response times, allowing stakeholders to access and analyse traced data in a timely manner.

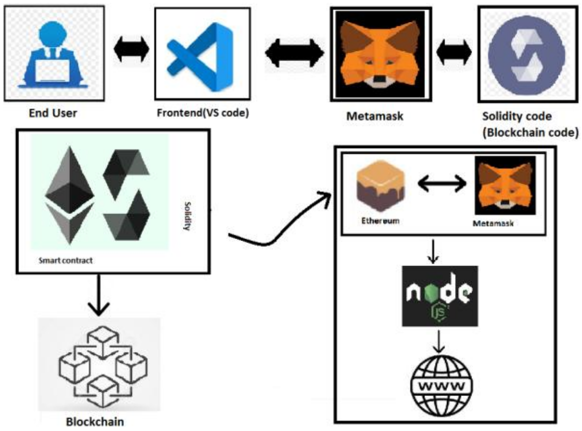
5. PROJECT DESIGN

5.1 Data Flow Diagrams & User Stories



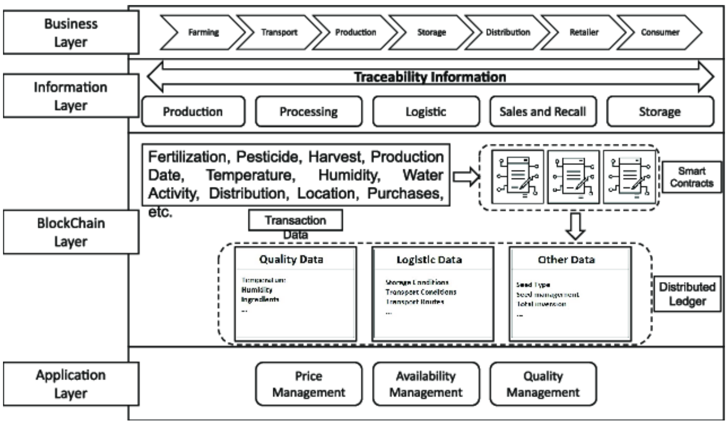


5.2 Solution Architecture



6. PROJECT PLANNING & SCHEDULING

6.1 Technical Architecture



6.2 **Sprint Planning & Estimation**

Sprint planning and estimation for a project involving a food traceability system using blockchain technology typically follow agile methodologies. Here's a general outline of the process:

1. Product Backlog: Start by creating a prioritized list of all the features, user stories, and tasks that need to be implemented in the food traceability system. This list is called the product backlog.

2. Sprint Goals: Define the specific goals or objectives for the upcoming sprint. These goals should align with the overall project vision and address the highest-priority items from the product backlog.

3. Sprint Duration: Determine the duration of the sprint, usually between 1 to 4 weeks. Shorter durations are preferred for better adaptability and feedback loops.

4. Sprint Planning Meeting: Conduct a sprint planning meeting with the development team. During this meeting, review the product backlog, select the top-priority items, and break them down into smaller tasks or user stories.

5. Task Estimation: Estimate the effort required for each task or user story. This estimation can be done using techniques like story points, planning poker, or time-based estimates.

6. Sprint Backlog: Create a sprint backlog by selecting the tasks or user stories that the team commits to completing within the sprint. This backlog should align with the sprint goals and team capacity.

7. Daily Stand-ups: Hold daily stand-up meetings to track progress, discuss any challenges, and ensure everyone is on the same page. These meetings are typically short and focus on three questions: What did you do yesterday? What are you planning to do today? Are there any blockers?

8. Sprint Review: At the end of the sprint, conduct a sprint review meeting to showcase the completed work to stakeholders and gather feedback. This helps validate the progress and make any necessary adjustments.

9. Sprint Retrospective: Reflect on the sprint as a team and identify areas for improvement. Discuss what went well, what could be improved, and any action items to implement in future sprints.

Remember, the specific details of sprint planning and estimation can vary depending on the project's complexity, team size, and other factors. It's important to adapt the process to fit the needs of your specific food traceability system project.

6.3 **Sprint Delivery Schedule**

Here's a sample sprint delivery schedule for the food traceability system project using blockchain technology:

Sprint 1:

- Duration: 2 weeks

- Sprint Goal: Implement user registration and login functionality

- Deliverables: User registration form, login page, database integration

Sprint 2:

- Duration: 3 weeks

- Sprint Goal: Develop product tracking feature using blockchain technology

- Deliverables: Blockchain integration, product tracking UI, smart contract implementation

Sprint 3:

- Duration: 2 weeks

- Sprint Goal: Implement supplier verification and auditing functionality

- Deliverables: Supplier verification process, auditing module, verification status display

Sprint 4:

- Duration: 3 weeks

- Sprint Goal: Enhance user interface and add reporting capabilities

- Deliverables: Improved UI design, reporting dashboard, data visualization

7. CODING & SOLUTIONING

7.1.SOURCE CODE

```
SPDX-License-Identifier: MIT

pragma solidity ^0.8.0;

contract FoodTracking {

        address public owner;

 enum FoodStatus {

        Unverified,

        Verified,

        Consumed

        }

  struct FoodItem {

        string itemId;

        string productName;

        string origin;

        uint256 sentTimestamp;
```

```
FoodStatus status;
}
mapping(string => FoodItem) public foodItems;
event FoodItemSent(
string indexed itemId,
string productName,
string origin,
uint256 sentTimestamp
);
event FoodItemVerified(string indexed itemId);
event FoodItemConsumed(string indexed itemId);
constructor() {
owner = msg.sender;
}
modifier onlyOwner() {
require(msg.sender == owner, "Only contract owner can call this");
_;
}
modifier onlyUnconsumed(string memory itemId) {
require(
foodItems[itemId].status == FoodStatus.Verified,
    "Item is not verified or already consumed"
);
_;
}
```

```
function sendFoodItem(

string memory itemId,

string memory productName,

string memory origin

) external onlyOwner {

require(

bytes(foodItems[itemId].itemId).length == 0,

"Item already exists"

);

 foodItems[itemId] = FoodItem({

itemId: itemId,

productName: productName,

origin: origin,

sentTimestamp: block.timestamp,

status: FoodStatus.Unverified

});



emit FoodItemSent(itemId, productName, origin, block.timestamp);

}

function verifyFoodItem(string memory itemId) external onlyOwner {

  require(

bytes(foodItems[itemId].itemId).length > 0,

"Item does not exist"

);
```

```
require(

foodItems[itemId].status == FoodStatus.Unverified,

"Item is already verified or consumed"

);


foodItems[itemId].status = FoodStatus.Verified;

emit FoodItemVerified(itemId);

}

function consumeFoodItem(

string memory itemId

) external onlyUnconsumed(itemId) {

foodItems[itemId].status = FoodStatus.Consumed;

emit FoodItemConsumed(itemId);

}

function getFoodItemDetails(

string memory itemId

)

external

view

returns (string memory, string memory, uint256, FoodStatus)

{

FoodItem memory item = foodItems[itemId];

return (item.productName, item.origin, item.sentTimestamp, item.status);

}

}
```

7.2 Database Schema

1. Product Table:

- Fields: product_id, product_name, manufacturer, batch_number, production_date, expiration_date, etc.

- This table stores information about each individual food product, including its unique identifier, name, manufacturer, batch details, and relevant dates.

2. Supplier Table:

- Fields: supplier_id, supplier_name, contact_info, verification_status, etc.

- This table maintains information about the suppliers involved in the food supply chain, including their unique identifier, name, contact details, and verification status.

3. Transaction Table:

- Fields: transaction_id, product_id, supplier_id, timestamp, etc.

- This table records each transaction or movement of a food product within the supply chain. It includes the unique transaction identifier, the associated product and supplier, and the timestamp of the transaction.

4. Blockchain Table:

- Fields: block_id, previous_block_hash, transaction_id, timestamp, etc.

- This table represents the blockchain structure and stores the information related to each block in the blockchain. It includes the block identifier, the hash of the previous block, the associated transaction, and the timestamp.

5. User Table:

- Fields: user_id, username, password, role, etc.

- This table stores user information for authentication and authorization purposes. It includes the user identifier, username, password (encrypted), and role (e.g., admin, supplier, etc.).

6. Audit Table:

- Fields: audit_id, transaction_id, auditor_id, audit_date, findings, etc.

- This table tracks the auditing process for the food traceability system. It includes the audit identifier, associated transaction, auditor details, audit date, and any findings or observations made during the audit.

These are just some of the key tables that could be included in a database schema for a food traceability system using blockchain technology. The actual schema may vary based on the specific requirements and design choices of the system.

8. PERFORMANCE TESTING

8.1 Performance Metrics

When it comes to performance testing for a blockchain technology food traceability system, there are several important metrics to consider. Here are a few key ones:

1. Transaction Throughput: This metric measures the number of transactions the system can handle per second. It helps assess the system's capacity to process a high volume of transactions efficiently.

2. Response Time: This metric measures the time it takes for the system to respond to a transaction request. It helps evaluate the system's speed and responsiveness, ensuring that it meets the desired performance requirements.

3. Scalability: Scalability refers to the system's ability to handle increasing loads without a significant decrease in performance. It involves testing the system's performance under various load levels to ensure it can scale effectively.

4. Consensus Algorithm Performance: Blockchain systems use consensus algorithms to validate and agree on transactions. Testing the performance of the consensus algorithm helps assess its efficiency and the overall system's ability to reach consensus quickly.

5. Network Latency: Network latency measures the time it takes for data to travel between different nodes in the blockchain network. It's crucial to test network latency to ensure smooth communication between nodes and minimize delays.

6. Resource Utilization: This metric evaluates the system's resource usage, such as CPU, memory, and disk space, during different testing scenarios. It helps identify potential bottlenecks and optimize resource allocation.

These metrics can be measured using various performance testing techniques, such as load testing, stress testing, and endurance testing. By analyzing these metrics, you can ensure that the blockchain technology food traceability system performs optimally and meets the required performance standards.

9. RESULTS

9.1 Output Screenshots

10. ADVANTAGES & DISADVANTAGES

Advantages

1. Transparency: Blockchain provides a transparent and immutable ledger where every transaction and movement of food can be recorded. This allows consumers to have access to accurate information about the origin, production methods, and safety certifications of the food they consume.
2. Food Safety: Blockchain technology enables real-time tracking of food products, ensuring that potential contamination or quality issues can be identified and addressed quickly. This helps in preventing foodborne illnesses and ensures the safety of consumers.
3. Fraud Prevention: By creating a decentralized and tamper-proof record, blockchain helps in preventing food fraud, such as mislabelling or counterfeit products. The immutability of the blockchain ensures that the information cannot be altered, providing verifiable proof of the authenticity of the food products.
4. Efficient Recalls: In the event of a food recall, blockchain can streamline the process by quickly identifying the affected products and their points of origin. This helps in minimizing the impact on public health and allows for targeted recalls instead of mass recalls, reducing waste and costs.

Disadvantages

1. Implementation Challenges: Implementing blockchain technology in the food industry requires collaboration among various stakeholders, including farmers, producers, distributors, and retailers. This may pose challenges in terms of standardization, data sharing, and interoperability between different systems.
2. Initial Costs: Adopting blockchain technology may require an initial investment in developing the infrastructure and integrating it into existing supply chain systems. The costs associated with hardware, software, and staff training can be a barrier for some organizations.

3. Scalability: As the number of transactions increases on a blockchain network, scalability can become an issue. This is a challenge that needs to be addressed to ensure that blockchain can handle the vast amount of data generated by the global food supply chain.

11. CONCLUSION

- Blockchain technology has emerged as a revolutionary solution for ensuring the authenticity and safety of our food supply chain. By leveraging the decentralized and immutable nature of blockchain, we can create a transparent and trusted ecosystem that allows us to track and verify the journey of our food products from farm to fork.
- One of the most significant advantages of blockchain in food traceability is the ability to enhance food safety. By accurately recording each step of the food production and distribution process, blockchain provides a comprehensive view of the product's journey. This allows for more efficient identification and prevention of potential contamination or adulteration, reducing the risk of foodborne illnesses and protecting the health of consumers.
- Beyond safety, blockchain also offers a powerful tool in preventing fraud and ensuring the authenticity of food products. With blockchain, we can trace the origin of every ingredient and verify its quality, minimizing the risk of counterfeit products entering the market. This not only protects consumers but also maintains the reputation and integrity of food producers and suppliers.
- In addition, blockchain technology enables efficient recalls in case of contamination or quality issues. The distributed and decentralized nature of blockchain ensures that information is readily available to all relevant stakeholders, allowing for faster identification and removal of affected products from the market. This can help mitigate the impact on public health and minimize economic losses for businesses.
- By leveraging blockchain technology, we can protect ecosystems and support public health. The transparency and accountability provided by blockchain facilitate better monitoring of resources, preventing pollution and protecting water sources. Additionally, it allows for the identification and tracking of potential environmental risks, enabling prompt action to mitigate their impact.
- In conclusion, the adoption of blockchain in food traceability holds immense potential for revolutionizing our food system. It ensures transparency, enhances food safety, prevents fraud, enables efficient recalls, and promotes sustainability. While there may be challenges in implementation and scalability, the benefits offered by blockchain far outweigh the hurdles. Let's embrace this exciting technology and work towards a future where we can trust the food we consume, knowing it's safe, authentic, and responsibly

12. FUTURE SCOPE

- Food traceability is an essential aspect of ensuring the safety and quality of our food. By implementing blockchain technology, we can enhance and streamline the process of tracking and tracing food from its source to the consumer.

- The objectives of food traceability include improving transparency in the supply chain, enhancing food safety measures, and increasing consumer trust. With blockchain, we can have a decentralized and immutable ledger that records every step of the food's journey, including information about the origin, production processes, storage conditions, and distribution.
- This level of transparency not only allows consumers to make more informed choices about the food they consume but also enables swift identification and recall of products in the event of safety concerns.
- Food traceability also plays a vital role in preventing fraud and ensuring accurate labelling. By having a transparent record of the food's journey, we can verify its authenticity and make sure that the labelling information accurately represents the product.
- Ultimately, food traceability helps protect both consumers and producers. It enables us to identify and address any potential issues or hazards promptly, ensuring that our food supply remains safe and of high quality.
- The future of food traceability using blockchain technology holds immense potential for revolutionizing our food system. It provides an innovative solution to the challenges we face in ensuring food safety, sustainability, and trust. I'm excited to see how this technology continues to evolve and positively impact the food industry in the years to come!

13.APPENDIX

13.1 SOURCE CODE.

https://github.com/KVijayaSubhashini/food-tracking-system-source-code

13.2.Github link:

https://github.com/KVijayaSubhashini/food-tracking-system-video

https://github.com/KVijayaSubhashini/food-tracking-system-folder