FOOD TRACKING SYSTEM USING BLOCKCHAIN

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1. INTRODUCTION

1.1 Project Overview

The awareness of protecting human health, which has increased on a global scale in recent years, has also shown itself in the food industry, and it has gained great importance that food be safe in order to lead a healthy life. Access to and the consumption of safe food is a right that every person should have. Food safety covers the whole process from the production stage of the food until it reaches the consumer [1]. More than 60% or about 1 billion tons of food is wasted within the supply chain while harvesting, processing, shipping, and storing [2]. For instance, nearly 492 million tons of perishable food were wasted in the year 2011 because of the ineffective and poor management of the food tracking systems [3].

According to the FAO (UN Food and Agriculture Organization), food security is defined as the ability of every person to have access to sufficient, safe, and nutritious food at all times to lead an active and healthy life [4]. Food safety is possible by taking every step of the food under control in the whole process, starting from the raw material until it reaches our table. Especially with the spread of digitalization, it is expected that the number and success of food tracking systems will increase [5]. The benefits of digitalization will be most clearly and largely achieved through the use of emerging technologies.

With the maturation and spread of emerging technologies, it has started to become a part of our daily life, shaping life and paving the way for digitalization [6]. One of the main reasons for digitalization is to reduce or even eliminate the need for manpower [7]. Undoubtedly, one of the prominent technologies at this point is blockchain technology, which is the infrastructure of cryptocurrencies such as Bitcoin, and many application areas have begun to emerge with the possibility of making transactions without intermediaries. Due to the advantages offered by blockchain technology, it has recently gained the notion of being the technological basis on which many applications are developed. It can be used in many different areas, such as smart city applications, IoT, health, energy management, and land registration systems [8]. Blockchain-based security approaches in remote patient monitoring using IoT devices are seen in the literature. In addition, blockchain-based cryptographic technologies could be used for deployment in the IoT [9]. Moreover, especially in recent times, we see that blockchain technology is used even in social media and content management, which is the abandonment of daily life. It is even seen that a naive blockchain- and watermarking-based social media framework is proposed to control fake news propagation [10]. As can be seen from all these examples, it is seen that blockchain technology can be applied in many different areas and the results obtained to make a significant contribution.

To define blockchain technology, it is a technology that eliminates the need for a central trust or authority, allowing trust to be distributed to the participants in the system. This technology can be defined as a decentralized database, and it is a chain of blocks, each of which contains numerical information. These blocks store a set of information or data in general terms. These sets of information hold more transactional information than storing data such as videos or images. After being filled with transactional data, the blocks are chained to the previous filled block. It also contains information such as the time the block was created (timestamp), the hash code of the block, the hash code of the previous block, the index information, and the nonce value. In the blockchain network, there are copies of the database at all parties of the distributed system. Keeping each of these copies in a distributed manner causes the data to be taken from a single center and moved to live in a multi-environment, making it difficult for potential attackers to

be successful. When transactional information arrives on the network, this information is transmitted to nodes in the network. All nodes in the network record this transactional information in their block. It should be noted here that a copy of the blockchain is kept on all the nodes. Once the blocks are filled with enough transaction information (or even just one transaction information), this block needs to be added to the blockchain. When the advantages offered by the blockchain technology and the beneficial results obtained in the application examples are evaluated, it is seen that it can be used in many different areas, determined by the needs. One of these areas is food tracking, which will be one of the most important problems of today and possibly the future. This emerging technology has the potential to take food tracking systems to a new dimension.

A food shortage, which has increased with the climate crisis, will be one of the biggest problems of the world, together with water scarcity, in the future and will damage the sustainability of the food supply system. With the effect of the COVID-19 pandemic, food resources are decreasing, and food prices are rising all over the world. The decrease in food sources increases the importance of food tracking even more. The exorbitant price increases after the COVID-19 pandemic are the most concrete indicators of this. Blockchain-based food tracking systems will be of critical importance because they will prevent exorbitant price increases with their contribution to food tracking processes, such as reliability and transparency. In this study, the establishment of a blockchain-based food tracking system in Turkey, its performance comparison, the operation of the system, and the results will be discussed.

This paper not only presents the establishment of a blockchain-based food tracking system in Turkey but also shows the comparison of the performance data of the established blockchain-based system with other blockchain infrastructures and the food tracking system without the blockchain layer. With the proposed system, reliability and transparency, as well as preventing exorbitant price advantages are targeted. The rest of the paper is organized as a literature review related to blockchain and its applications on food tracking systems, the methods and applications, the results and discussion, and finally, the conclusion.

1.2 Purpose

One of the foremost blockchain-based food tracking systems is the “Food Trust” system developed by IBM. Announced for the first time in 2017, Food Trust has provided traceability in the food supply chain to 80 different brands so far by using blockchain technology. With this traceability, the supply process from producers to consumers can be followed in detail. IBM’s open-source technology based on Hyperledger Fabric allows companies to set their own rules on the system. It is argued that the traceability offered by the Food Trust not only helps food safety but also helps producers with food freshness, sustainability, and waste. Announcing that more than 5 million food products already on the shelves are included in the system, IBM seems confident that this platform will grow strongly. Among the companies using this application are giants such as Dile, Kroger, McCormick and Company, Nestle, Tyson Foods, and Unilever [**11**].

Walmart has used blockchain to record where every piece of meat it buys from China comes from, where it is processed, where it is stored, and all transactions related to its sale, along with its historical course. All detailed information about the farm where the meat comes from, the factory where it is processed, the batch number of the product, the storage temperature of the product, and transportation can be tracked on the blockchain. In addition to the benefits of processing speed, information sharing, and transparency, the main purpose is summarized as increasing food safety [**12**].

Provenance has conducted a blockchain-based pilot project in Indonesia to transparently track the movement of products from sea to table in the fishing industry. The seafood trade consists of a very large fishing network, and it is a very difficult sector to control quality. There is no reliable audit in the sector. This project aims to help stop illegal, excessive, harmful to the sea and the environment, and non-sanitary fishing violations in the tuna fish industry. Thus, consumers will be able to view the source of the food they supply transparently, and a legal basis will be established to combat illegal fishing. With the use of this example, the aim is that the use of blockchain technology will facilitate transparency, tracking, and auditing, thus ensuring the safety of food products, preventing illegal and excessive fishing, and preventing damage to the environment [13].

Kim proposes a blockchain-based traceability system with different ontologies, where each one could accomplish and be part of certain transactions. He offers the use of smart contracts. Ethereum, with the Solidity programming language, was used in his study [14]. Feng Tian et al. propose a blockchain solution for agriculture traceability to ensure that the HACCP principles and requirements are addressed during the production, transportation, and preservation of a product [15].

Moreover, Daniel Tse et al. focus on the increasingly serious problem of food safety in China and propose a blockchain solution for the agriculture supply chain, based on the information and transaction security between all the involved parties. In this work, a PEST (political, economic, social, and technological) environment analysis took place to define the challenges and the opportunities of the DLT (Distributed Ledger Technologies) solution [16].

In addition, Francesco Marinello et al. offer a blockchain-based solution focusing on the animal products supply chain in Italy [17]. Kumar et al. propose a rice supply chain system that uses blockchain technology to assure the safety of rice during its flow through the supply chain [18].

Maria Elena Latino et al. propose another interesting idea regarding the agriculture supply chain and the use of Industry 4.0 principles [19]. They refer to the idea of food democracy, according to which consumers are considered citizens and the food is not a good but a civil right. The authors advertise the idea of voluntary traceability and combine it with Industry 4.0 technologies. The significance of voluntary traceability is highlighted, focusing on the volume and the quality of the data collected for each product, as well as the need for a big data platform to handle them.

Islam and others published work about the visualization of food supply chain management. Their research aims to propose a new visualization approach that allows supply chain operators to collaborate effectively in the design process of FTSs capable of maintaining streamlined information flow, minimizing information loss, and improving supply chain performance [20].

Bahga et al. proposed work to monitor the food supply chain tracking system on a cloud-based architecture. The proposed system, called CloudTrack, provides the global information of the entire fleet of food supply vehicles and is proposed to be used to track and monitor a large number of vehicles in real time [21].

Caro et al. propose an integrated solution of a blockchain platform named AgriBlockIoT in the agriculture supply chain [22]. AgriBlockIoT is a fully distributed system that uses blockchain technology in combination with IoT devices to collect and distribute traceability data. The

proposed solution was tested with two Ethereum and Hyperledger Sawtooth blockchain platforms. AgriBlockIoT enables the integration of IoT and blockchain technologies, creating transparent, fault-tolerant, immutable, and auditable records which can be used for an agri-food traceability system.

Tian proposes a blockchain-based food tracking system, especially to solve the recent problems related to food tracking in China. Arguing that traditional agricultural supply logistics systems do not fully meet market needs, he proposes a more dynamic RFID-based food supply chain management system. With the proposed system, it is advocated that traceability with reliable information in the entire agri-food supply chain effectively guarantees food safety by collecting, transferring, and sharing the original data of agri-food in production, processing, storage, distribution, and sales connections [**23**].

Contributions of Proposed Study

The novelty and contributions of this proposed study are:

- A total of 0.038 s for latency was gathered with the proposed system, which is 435 times better than Ethereum, one of the most popular blockchain infrastructures.
- A transmission per second value of 285, reception per second value of 335, and CPU load value of 19.22 are obtained with the proposed blockchain-based system.
- Through the proposed blockchain-based system to be established, suppliers that make unfair price increases in the case of a food shortage, which will become a bigger problem in the coming periods due to the COVID-19 pandemic, will be prevented.
- It is the first study in which the live use of the blockchain-based food tracking system is carried out and the satisfaction survey is carried out.
- A total of 75.31% of the users who use the application liked the interface of the application; 97.54% of the users stated that they found the application extremely useful and that they would like to use it again in the future.

2. LITERATURE SURVEY

2.1 Existing problem

SPECIFY THE BUSINESS PROBLEM

The fundamental business problem in a Food Tracking System employing blockchain technology is the pervasive deficiency of transparency and accountability within the intricate web of the food supply chain. This systemic issue is characterized by a profound opacity in the movement of food products from their origin through various stages of production, processing, distribution, and ultimately, consumption. This deficiency in transparency engenders a host of critical challenges for stakeholders across the food industry. First and foremost, consumers are left largely uninformed about the provenance, handling, and processing of the food they purchase. This lack of information undermines their ability to make informed choices based on personal preferences, dietary restrictions, or ethical considerations. Consequently, consumer trust in the industry is eroded, potentially leading to decreased brand loyalty and market share for food producers and retailers.

Moreover, this opacity poses substantial risks to public health and safety. In the absence of clear, accessible information, it becomes exceedingly difficult to promptly identify and address issues such as contamination, allergen concerns, or product recalls. This can result in delayed responses, further endangering the well-being of consumers.

Retailers and distributors also face formidable challenges due to this lack of transparency. They are often compelled to rely on trust in their suppliers and their certifications, with limited means of independently verifying the accuracy of claims regarding a product's origin, quality, or production methods. This reliance can leave them vulnerable to unwittingly distributingsubstandard or misrepresented products.

Regulators, responsible for overseeing the safety and integrity of the food supply chain, are likewise hindered by this lack of transparency. Their ability to enforce regulations, conduct investigations, and ensure compliance is hampered by the absence of a reliable, immutable record of the chain of custody for food products.

The issue of accountability further exacerbates the problem. With no verifiable ledger to track transactions and interactions within the supply chain, assigning responsibility in the event of a problem becomes a complex and often contentious task. This lack of accountability creates an environment where bad actors may operate with relative impunity, potentially engaging in fraudulent activities, counterfeit products, or other illicit practices.

In sum, the lack of transparency and accountability within the food supply chain represents a critical business problem with far-reaching implications. It compromises consumer safety, erodes trust in the industry, and creates inefficiencies and risks for all stakeholders involved. The integration of blockchain technology offers a promising solution, providing a secure, immutable ledger that records every step of the supply chain, ensuring transparency, traceability, and accountability at every juncture. By addressing this foundational issue, blockchain technology has the potential to revolutionize the food industry, making it safer, more reliable, and ultimately more trustworthy for all participants.

Business Requirements

Absolutely, establishing end-to-end transparency and traceability within the food supply chain is a crucial business requirement for a Food Tracking System utilizing blockchain technology.

Here's an elaboration of why these requirements are paramount: Consumer Trust and Safety: End-to-end transparency assures consumers that the food they purchase is safe, authentic, and meets their quality expectations. This trust is fundamental for consumer loyalty and brand reputation.

Regulatory Compliance: It ensures compliance with food safety and quality regulations. Detailed, immutable records aid in audits and investigations, reducing the risk of non-compliance fines and penalties. Contamination and Recall Management: Rapid traceability allows for swift

identification and recall of potentially contaminated or unsafe products, reducing the scope and impact of recalls.

Supply Chain Efficiency: Transparent tracking of food products reduces inefficiencies, such as delays, errors, and misplacements, ultimately leading to cost savings and smoother operations. Quality Assurance and Control: The ability to trace each step in the supply chain allows for proactive quality control measures, reducing the likelihood of substandard or unsafe products reaching consumers. Ethical and Sustainable Sourcing: It enables verification of claims related to ethical practices (e.g., fair trade, organic) and sustainable sourcing, which are increasingly important to consumers.

Market Differentiation: A Food Tracking System on the blockchain can be a powerful marketing tool, as it showcases a commitment to transparency and quality, setting businesses apart in a competitive market. Data-Driven Decision Making: Accurate and real-time data collected through blockchain technology allows for data-driven decision-making and process optimization, improving overall supply chain management.

Supplier Accountability: End-to-end transparency holds suppliers accountable for their claims and practices. This discourages dishonest or unethical behavior within the supply chain.

Crisis Response and Public Relations: In the event of a food safety issue, having a transparent system in place can demonstrate a commitment to consumer safety, potentially mitigating reputational damage.

Global Supply Chains: Particularly important for international supply chains, end-to-end transparency helps navigate complex customs, tariffs, and compliance requirements. Technology Adoption and Innovation: Embracing blockchain technology positions a business at the forefront of technological innovation, potentially attracting tech-savvy consumers and partners.

Data Security and Integrity: Blockchain's decentralized nature ensures data security and integrity, reducing the risk of data tampering or hacking. In essence, the business requirements for establishing end-to-end transparency and traceability within the food supply chain are not only critical for safeguarding consumer health and trust but also for streamlining operations, ensuring compliance, and gaining a competitive edge in a rapidly evolving industry. By leveraging blockchain technology, businesses can address these requirements and revolutionize the way food products are tracked and managed throughout the supply chain.

SOCIAL OR BUSINESS IMPACT

Certainly, implementing a Food Tracking System using blockchain technology can bring about a multitude of social and business impacts. Here's an extensive

exploration of these impacts:

1. Enhanced Transparency and Trust: Blockchain's immutable ledger ensures that every step in the food supply chain is recorded and cannot be altered, providing consumers with

unprecedented transparency. This transparency builds trust, as consumers can trace the journey of their food products, knowing exactly where they came from.

2. Improved Food Safety and Quality: Rapid traceability allows for swift identification of contaminated or unsafe products, leading to quicker recalls and reducing the impact on public health. Producers and distributors are incentivized to maintain high-quality standards, knowing that any lapses will be quickly identified.

3. Reduced Fraud and Counterfeiting: The tamper-proof nature of blockchain significantly reduces the risk of fraudulent activities within the supply chain, such as counterfeit products or mislabeling.

4. Compliance with Regulations: The transparent nature of blockchain makes it easier to demonstrate compliance with industry regulations and certifications, reducing the risk of fines or penalties.

5. Efficient Supply Chain Management: Real-time updates on the status and location of food products lead to a more efficient and responsive supply chain, reducing delays and waste.

6. Empowering Consumers: Consumers can make more informed choices about the food they consume, based on personal preferences, dietary restrictions, and ethical considerations.

7. Ethical Sourcing and Sustainability: Blockchain can verify claims regarding ethical practices, fair trade, and sustainable sourcing, allowing consumers to support companies aligned with their values.

8. Strengthening Brand Reputation: Companies that adopt blockchain for food tracking demonstrate a commitment to transparency and quality, enhancing their brand reputation and consumer loyalty.

9. Crisis Response and Public Relations: In the event of a food safety issue or product recall, blockchain expedites the process of identifying and removing affected products, demonstrating a commitment to consumer safety.

10. Facilitating Market Access: Blockchain can help producers and exporters comply with international regulations, opening up new markets and opportunities for growth.

11. Data-Driven Insights: The data collected through blockchain technology can provide valuable insights into consumer preferences, supply chain efficiencies, and areas for improvement.

12. Reducing Food Waste: Real-time tracking and traceability can help identify inefficiencies in the supply chain, reducing the likelihood of food spoilage and waste.

13. Encouraging Innovation: The adoption of blockchain technology encourages innovation in supply chain management and opens up opportunities for new business models and partnerships.

14. Empowering Small Producers: Blockchain can level the playing field for small-scale producers, allowing them to compete on equal footing with larger players by showcasing their adherence to quality and ethical standards.

15. Regulatory Efficiency: Regulators can more easily verify compliance with food safety regulations, reducing the burden on inspection agencies and potentially leading to more targeted interventions. In conclusion, implementing a Food Tracking System using blockchain technology has the potential to revolutionize the food industry, providing benefits ranging from improved consumer safety and trust to more efficient supply chain management and ethical sourcing practices. While the adoption may require investment and collaboration, the long-term gains for both businesses and society as a whole are substantial. This technology has the power to reshape how we perceive, produce, and consume food.

2.2 References

Hyperledger Fabric was chosen as the infrastructure on which the proposed blockchain-based system will be developed. Another tool of Hyperledger, Hyperledger Explorer, was used to provide transparent visibility of transactions in the established Hyperledger Fabric-based system. The use of these two infrastructure elements is of great importance in terms of embodying transparency and reliability features. All smart contract transactions are carried out over the Hyperledger Fabric layer. Because blockchain transactions and processes require high performance, a need for a computer with high processing power has arisen. A device with NVIDIA GeForce RTX 3080 graphics card, Intel i7 12700KF processor, 16 GB RAM, and 1TB SSD has been determined and Ubuntu 20.04 operating system is chosen to be used.

The study will first start with a literature review of the blockchain technology-based food tracking system. In the current situation, the application examples in the market will be examined, and the academic studies will be used to guide the food tracking system that is planned to be developed. After the application examples are examined, the stage of realization of the study will be started. Firstly, the design will be carried out in line with the requirements of the system to be established. Secondly, the infrastructure to be used in the system to be developed will be decided. Many alternatives in the market offer the smart contracts infrastructure that is the basis of the blockchain-based system we plan to develop. Determining the appropriate one is of great importance for the success of the study and not to get to a dead end. After the system design and the smart contract infrastructure to be used are determined, the development phase of the application will begin. With the developed blockchain-based system, the comparison of the performance data of the established blockchain-based system with other blockchain infrastructures and the food tracking system without the blockchain layer will take place. Afterward, the implementation of the system in real-life will be performed and the results will be discussed. Then, the study will be concluded.

2.3 Problem Statement Definition(literature survey)

LITERATURE SURVEY OF FOOD TRACKING SYSTEM USING BLOCKCHAIN - TECHNOLOGY

*) One of the foremost blockchain-based food tracking systems is the "Food Trust" system developed by IBM. Announced for the first time in 2017, Food trust has provided traceability in food supply chain to 80 different brands so far by using blockchain technology. Announcing that more than 5 million food products already on the shelves are included in the system, IBM seems confident that this platform will grow strongly.

*) Walmart has used blockchain to record where every piece of meat it buys from china comes from, where it is processed, and all transaction related to its sale, along with its historical source. All detailed information about the farm where the meat comes from, the factory where it is processed, the storage temperature of the product and transportation can be tracked on the blockchain. In addition to the benefits of processing speed, information sharing and transparency, the main purpose is summarized as increasing food safety.

*) Pronunare has conducted a blockchain-based pilot project in Indonesia to transparently track the movement of products from sea to table in the fishing industry. The seafood trade consists of very large fishing networks, and it is very difficult sector to control quality. There is no reliable audit in sector. The aim is that the use of blockchain technology will facilitate transparency, tracking and auditing, thus the ensuring the safety of food products, preventing illegal and excessive fishing.

*) Daniel Tse et al. focus on the increasingly serious problem of food safety in china and propose a blockchain solution for the aquiculture supply chain, based on the information and transaction security between all the involved parties.

*) Francesco Marinello et al. offer a blockchain based solution focusing on the animal products supply chain in Italy. Kumar et al. propose a rice supply chain system that uses blockchain technology to assure the safety of rice during its flow through the supply chain.

*) Bagha et al. proposed work to monitor the food supply chain tracking system on cloud-based architecture. The proposed system, called cloud track, provides the global information of the entire fleet of food supply vehicles and it's proposed to be used to track and monitor a large number of vehicles in real time.

*) Caro et al. propose an integrated solution of a blockchain platform named Agri-Block IoT in the agriculture in the supply chain. Agri block IoT is a fully distributed system that uses blockchain technology in combination with IoT devices to collect and distribute traceability data. The proposed solution was tested with two Ethereum and hyperledger sawtooth blockchain platforms. Agri block IoT enables the integration of IoT and blockchain technologies, creating transparent and auditable records which can be used for an agri-food traceability system.

*) Tilan proposes a blockchain based food tracking based system, especially to solve the recent problem related to food tracking in China. Arguing that traditional agriculture supply logistic system

do not fully meet market needs, the proposes a more dynamic RFID-based food supply chain management system. with the proposed system, transferring and sharing the original data of agri-food in production, processing, storage, distribution, and sales connections.

CONTRIBUTIONS OF PROPOSED STUDY

⇒ As total of 0.038s for latency was gathered with the proposed system, which is 435 times better than Ethereum, one of the most popular blockchain Infrastructure.

⇒ A transmission per second value of 285, reception per second value of 335, and CPU load value of 19.22 are obtained with the proposed blockchain based system.

⇒ It is first study in which the full use of blockchain-based food tracking system is carried out and the satisfaction survey is carried out.

⇒ A total of 75.31% of users who use application liked the interface of application; 97.54% of the users stated that they found the application extremely useful and that they would like to use it again in the future.

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas

Empathy Map Canvas:

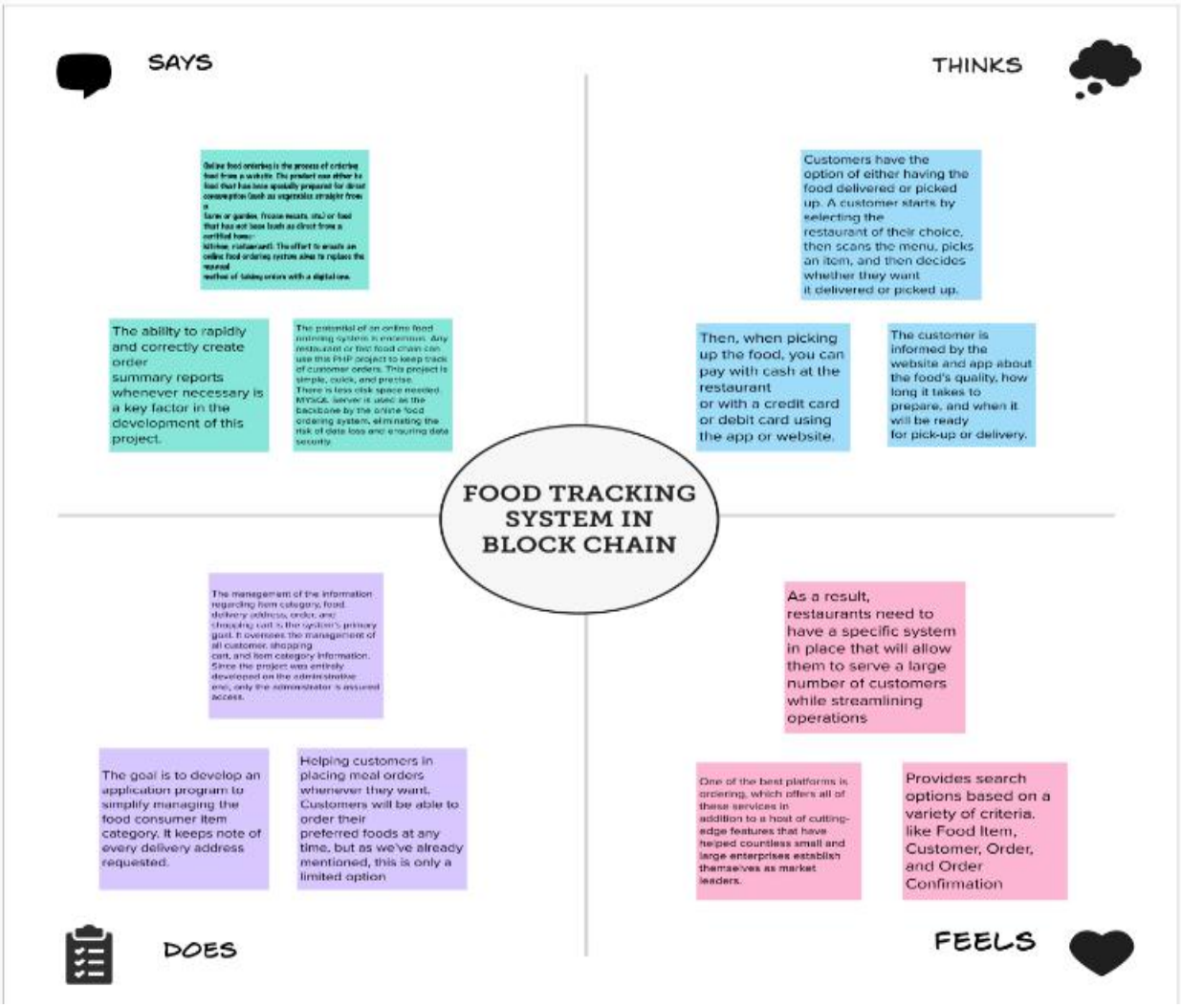
An empathy map is a simple, easy-to-digest visual that captures knowledge about a user's behaviours

and attitudes. It is a useful tool to helps teams better understand their users. Creating an effective

solution requires understanding the true problem and the person who is experiencing it. The exercise of

creating the map helps participants consider things from the user's perspective along with his or her

goals and challenges.



3.2 Ideation & Brainstorming

Brainstorm & Idea Prioritization Template:

Brainstorming provides a free and open environment that encourages everyone within a team to

participate in the creative thinking process that leads to problem solving. Prioritizing volume over value,

out-of-the-box ideas are welcome and built upon, and all participants are encouraged to collaborate,

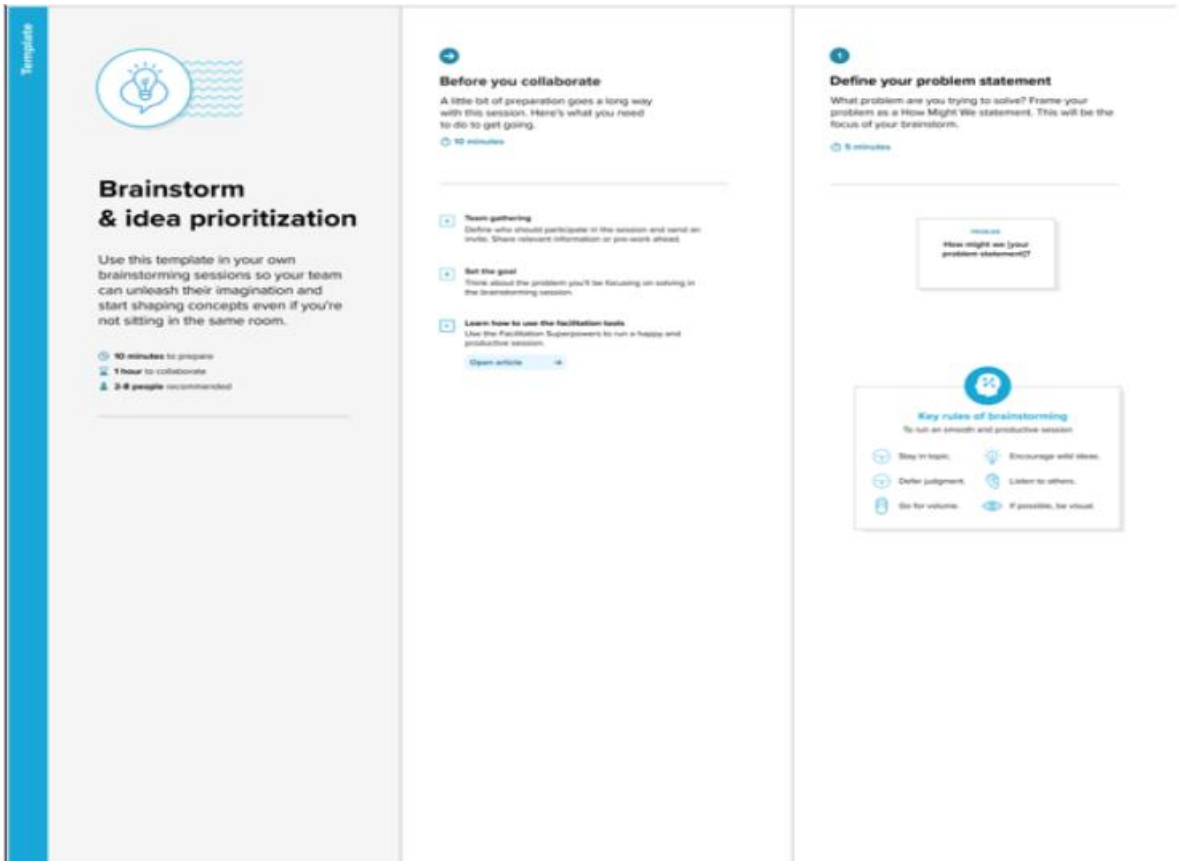
helping each other develop a rich amount of creative solutions. Use this template in your own

brainstorming sessions so your team can unleash their imagination and start shaping concepts even if

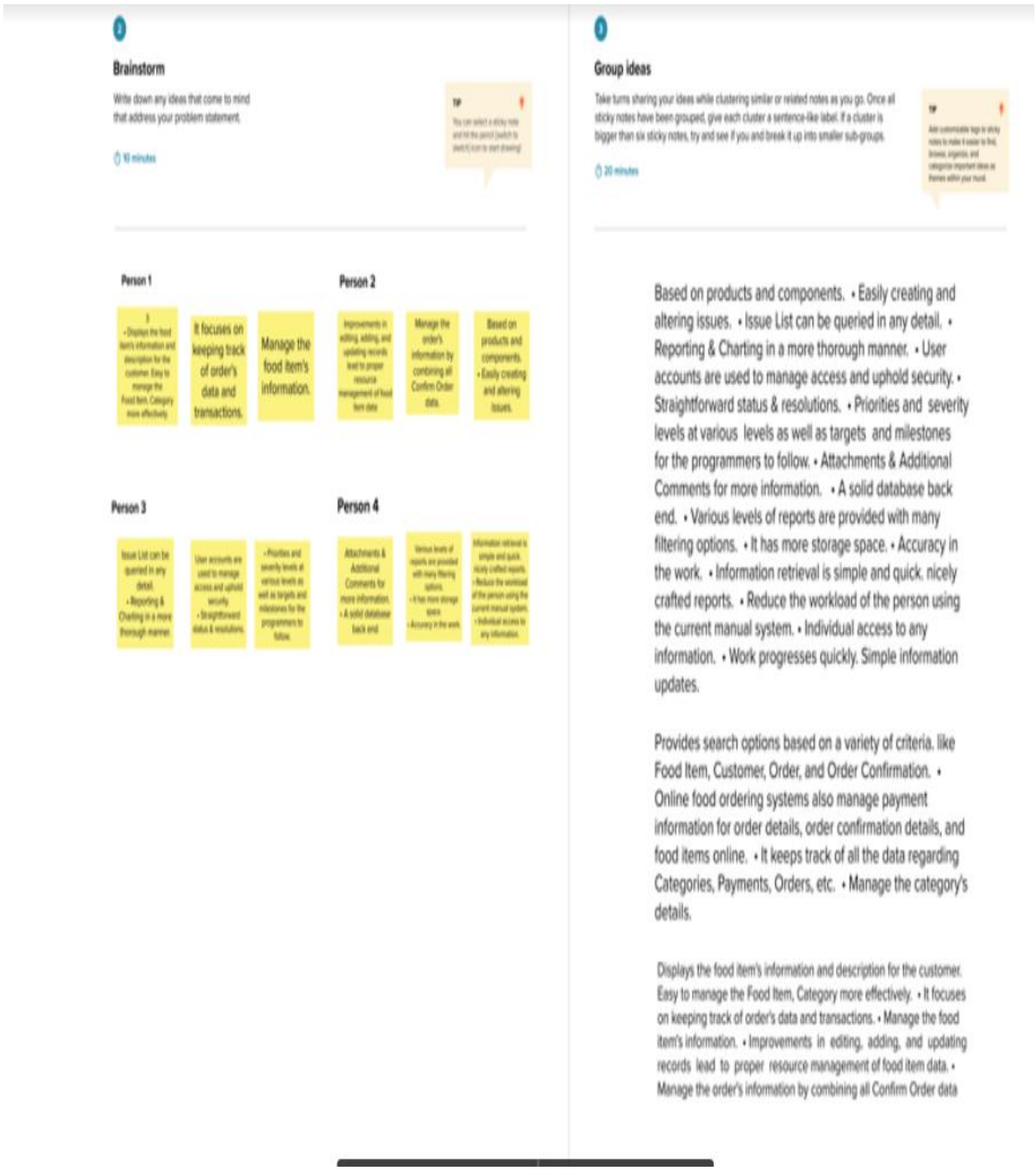
you're not sitting in the same room.

Reference: https://www.mural.co/templates/empathy-map-canvas

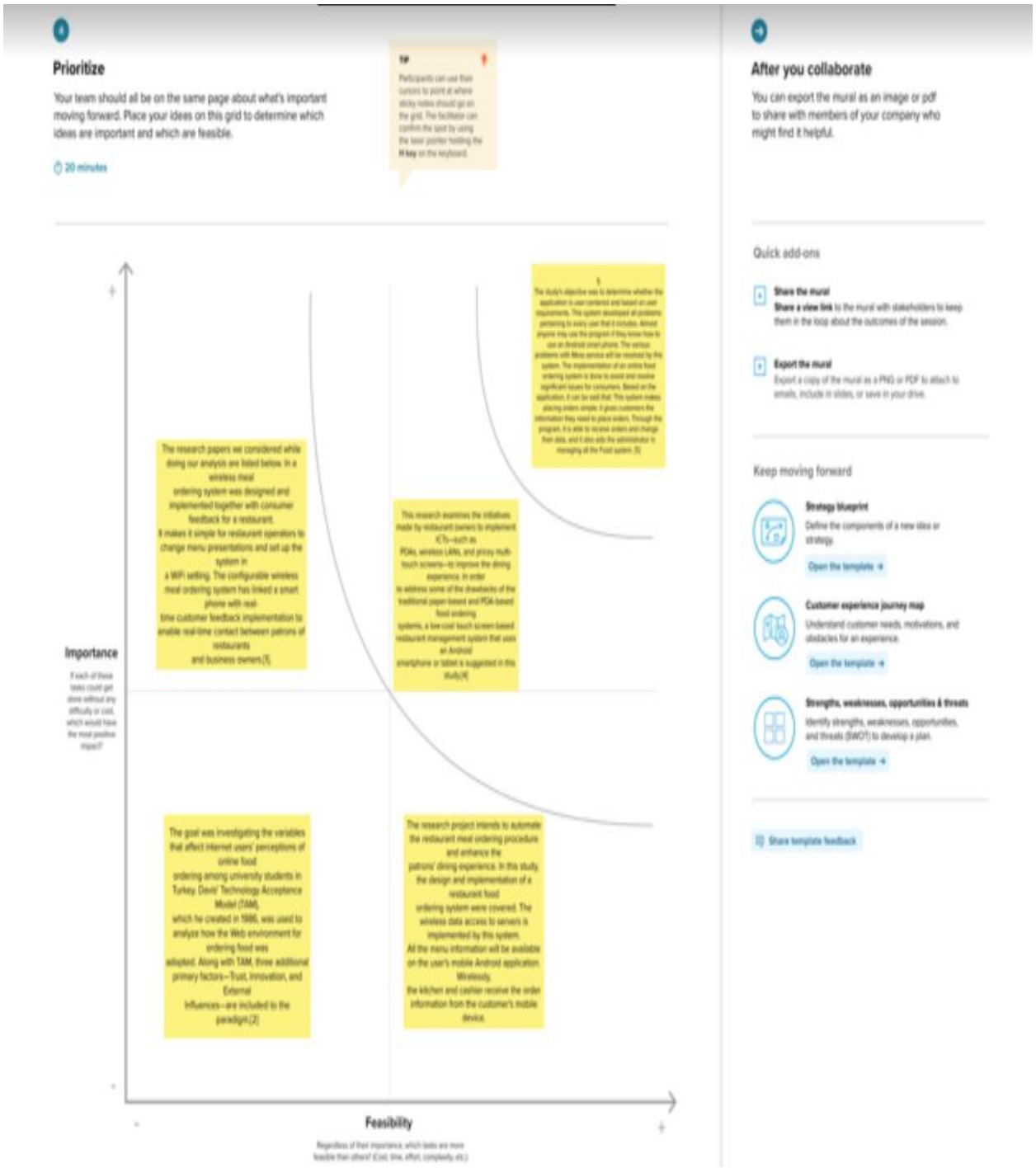
Step-1: Team Gathering, Collaboration and Select the Problem Statement



Step-2: Brainstorm, Idea Listing and Grouping



Step-3: Idea Prioritization



4. REQUIREMENT ANALYSIS

4.1 Functional requirement

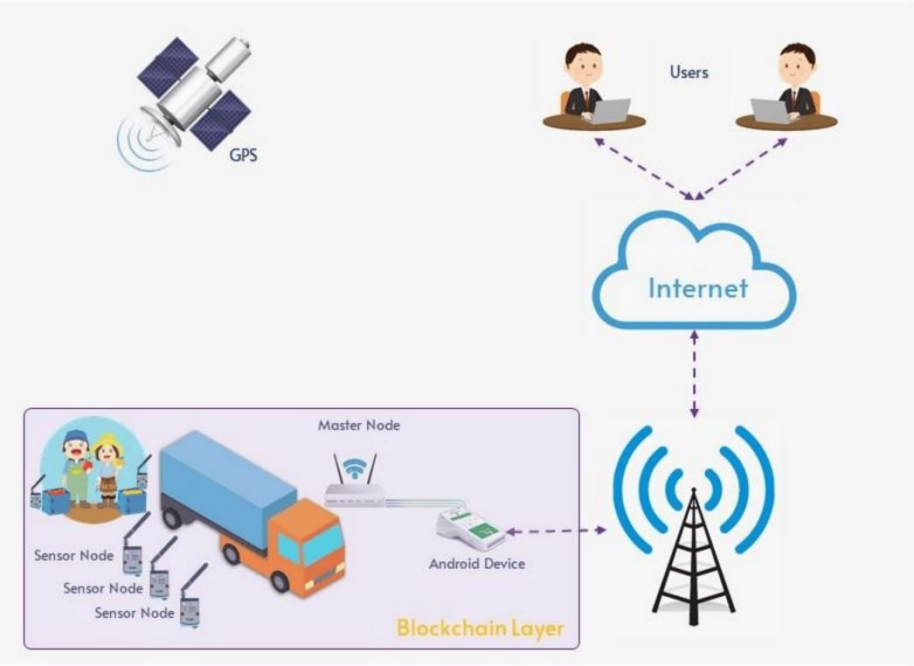
- **Planting the crop:** The producer records the number and type of seeds used during planting in the blockchain structure. With a smart contract to be used here, it can be checked that no more seeds are planted from the seed taken in the previous transaction.
- **Cultivation:** With the networked microcontrollers to be used here, information about the growing place of the product, how much water or sun it receives can be added to the blockchain. Again, when there is an anomaly with smart contracts, it can be recorded.
- **Harvest:** During the harvest of the planted product, adding the obtained amount to the blockchain with IoT devices can be automated and it can be determined whether the product is organic through the process from seed to harvest.

4.2 Non-Functional requirements

- **Production:** The amount delivered to the manufacturer can be added to the blockchain. In this way, it is possible to monitor how much loss is incurred in the transfer phase of the goods from the manufacturer to the manufacturer.
- **Delivery of the product to the retailer:** Using GPS technology, the delivery process of the product to the retailer can also be monitored with IoT devices. The quantity and freshness of the delivered product can be recorded on the blockchain.
- **Consumption:** The consumer can view the entire life cycle of this product, all data collected, with the help of a QR code. They can also observe how the pricing is conducted in all the above transactions.

5. PROJECT DESIGN

5.1 Data Flow Diagrams & User Stories



User Stories

While investing in technology, a detailed market analysis of the product to be produced with the relevant technology is of great importance in terms of obtaining successful outputs. The preparation of such reports requires significant experience, knowledge, and market monitoring. Some research companies conduct such research and present various reports, as technology companies cannot find the opportunity to make such a deep analysis in their daily routines and/or they may not have sufficient depth of knowledge. It is generally seen that large technology companies follow such external analyses while making technological investments and make investment decisions after analyzing their outputs. As one of these companies, Gartner is in the market; it is known as one of the world's leading companies in technology and market analysis. It is a prestigious company that follows emerging technologies and offers many detailed analyses. As expected, Gartner did not remain indifferent to the remarkable advantages offered by blockchain technology and researched this technology. In the report prepared as a result of the research, it is emphasized that the development and maturity of decentralized open blockchain applications have increased, but similar results have not yet been achieved in successful private enterprise blockchain projects. When the hypecycle in which the investigations are made, according to the types of blockchain applications examined, it is seen that financial applications are in the "enlightenment trend" stage; it is seen that it will pass to the level of maturity in between 2 and 5 years. Apart from the financial applications of blockchain technology, it is widely used. Smart contract applications, on the other hand, are currently in the "trough of disillusionment" stage and will take a little longer to reach maturity; but, in between 5 and 10 years, it is seen that this field will reach the level of maturity

5.2 Solution Architecture

POJECT PLANING & SHEDULING

FOOD TRACKING SYSTEM

Phase 1: Project Initiation

Define Objectives and Scope

Define the purpose and goals of the Food Tracking System.

Specify the features and functionalities to be implemented.

Market Research and Feasibility Study

Analyze the market for similar systems.

Assess the feasibility of implementing blockchain technology.

Team Formation and Roles Assignment

Identify team members and assign roles (e.g., project manager, blockchain developer, UI/UX designer, etc.).

Ensure that each member understands their responsibilities.

Legal and Regulatory Compliance

Identify legal requirements and regulations related to food tracking and blockchain implementation.

Establish a plan for compliance.

Resource Allocation

Allocate necessary resources (hardware, software, budget, etc.).

Procure any required tools or licenses.

Phase 2: System Design

System Architecture Design

Design the overall architecture of the Food Tracking System.

Define the components, modules, and their interactions.

Blockchain Technology Selection

Choose a suitable blockchain platform (e.g., Ethereum, Hyperledger, etc.) and consensus mechanism.

Decide on the smart contract language (e.g., Solidity).

Database Design

Design the database schema for storing food-related information.

Define data structures for blockchain transactions.

User Interface (UI) Design

Create wireframes and design mockups for the user interface.

Gather feedback and iterate on the designs.

Phase 3: Development (Week 7-14)

Smart Contract Development

Write and deploy smart contracts for food tracking on the chosen blockchain platform.

Implement necessary functions for data storage and retrieval.

Backend Development

Develop the backend systems for processing and validating food-related transactions.

Integrate with the blockchain using APIs.

Frontend Development

Implement the user interface based on the approved designs.

Ensure seamless interaction with the backend systems.

Integration Testing

Test the integration between the frontend, backend, and blockchain components.

Identify and rectify any issues or bugs.

Phase 4: Testing and Quality Assurance

Unit Testing

Conduct unit tests for individual components to ensure their correctness.

Functional Testing

Verify that the system functions according to the defined requirements.

Security Testing

Perform security assessments to identify and address vulnerabilities.

User Acceptance Testing (UAT)

Involve stakeholders and end-users to validate the system against their requirements.

Phase 5: Deployment and Launch

Deployment to Production Environment

Set up the production environment and deploy the Food Tracking System.

Monitoring and Maintenance

Implement monitoring tools to track system performance and security.

Establish a maintenance plan for ongoing updates and bug fixes.

Phase 6: Documentation and Training

Documentation

Create user manuals, technical documentation, and system architecture diagrams.

Training

Provide training sessions for users and administrators on how to use and maintain the system.

Phase 7: Evaluation and Feedback

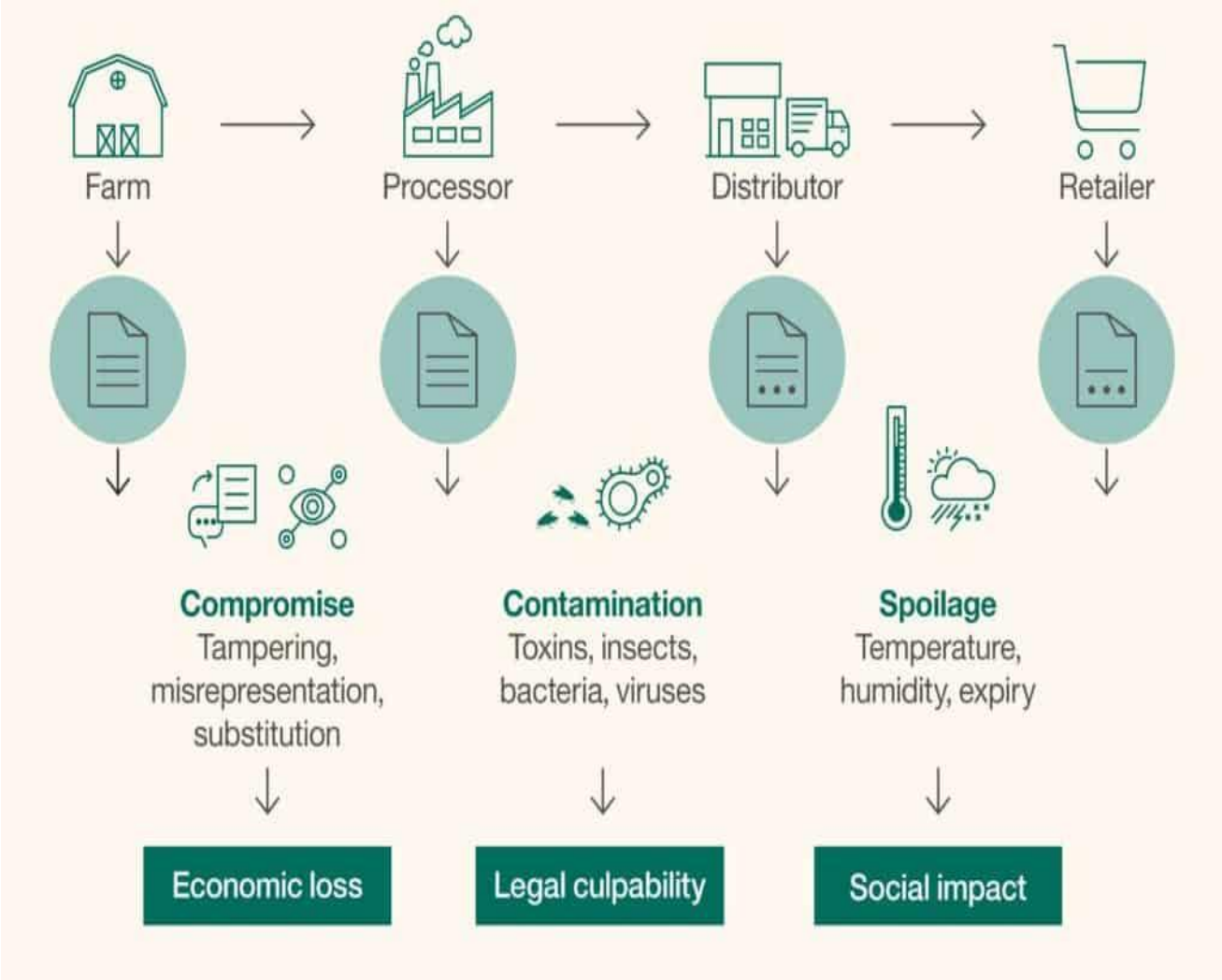
Post-Implementation Review

Evaluate the success of the project against initial objectives.

Feedback Collection

Gather feedback from stakeholders and end-users for future improvements.

TECHNICAL ARCHITECTURE

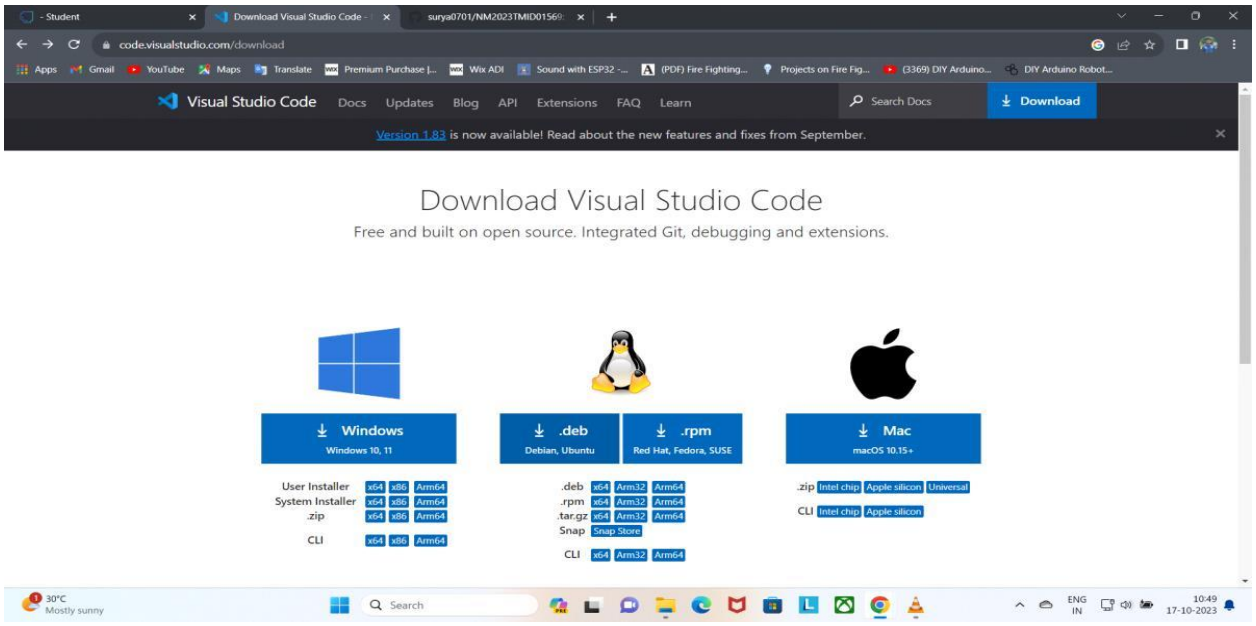


7. CODING & SOLUTIONING

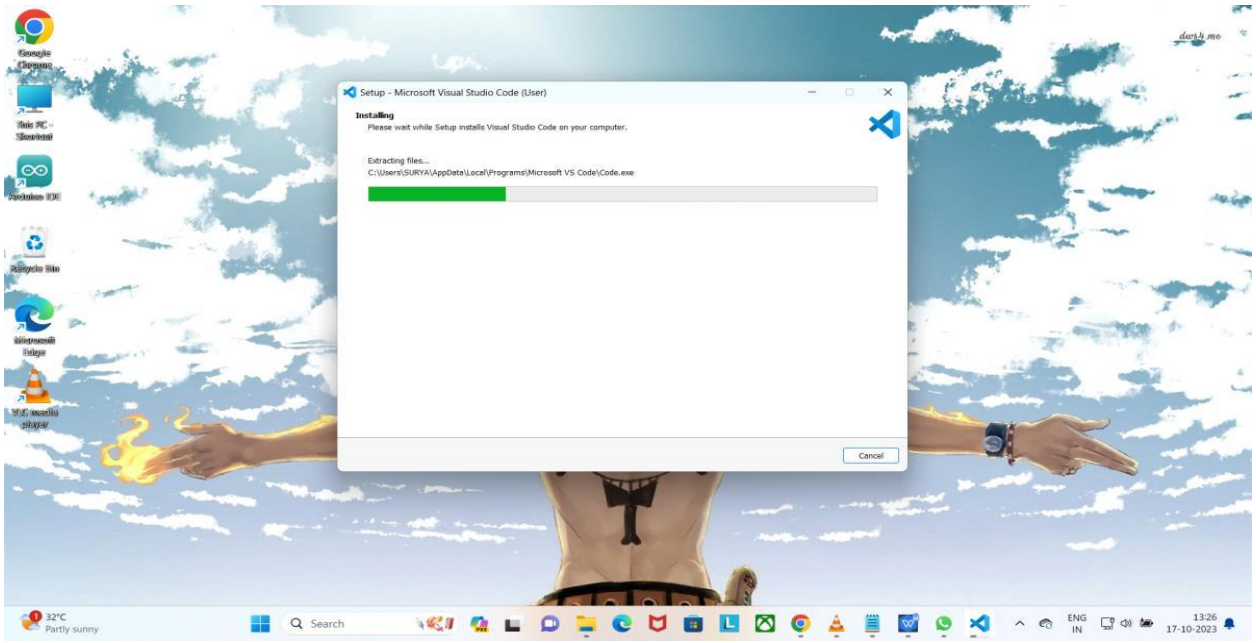
7.1 Feature 1

DOWNLOAD VS CODE

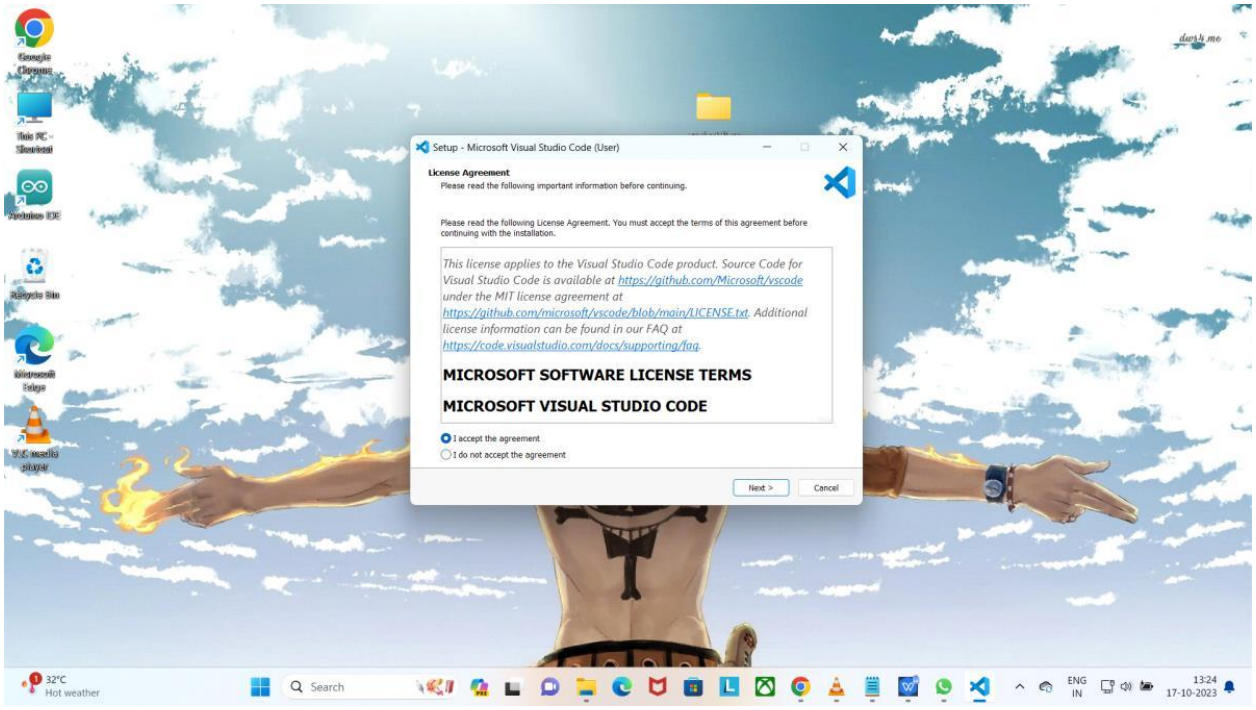
STEP 1:DOWNLOAD VS CODE HERE FROM THE LINK



STEP 2: Download the Visual Studio Code installer for Windows.

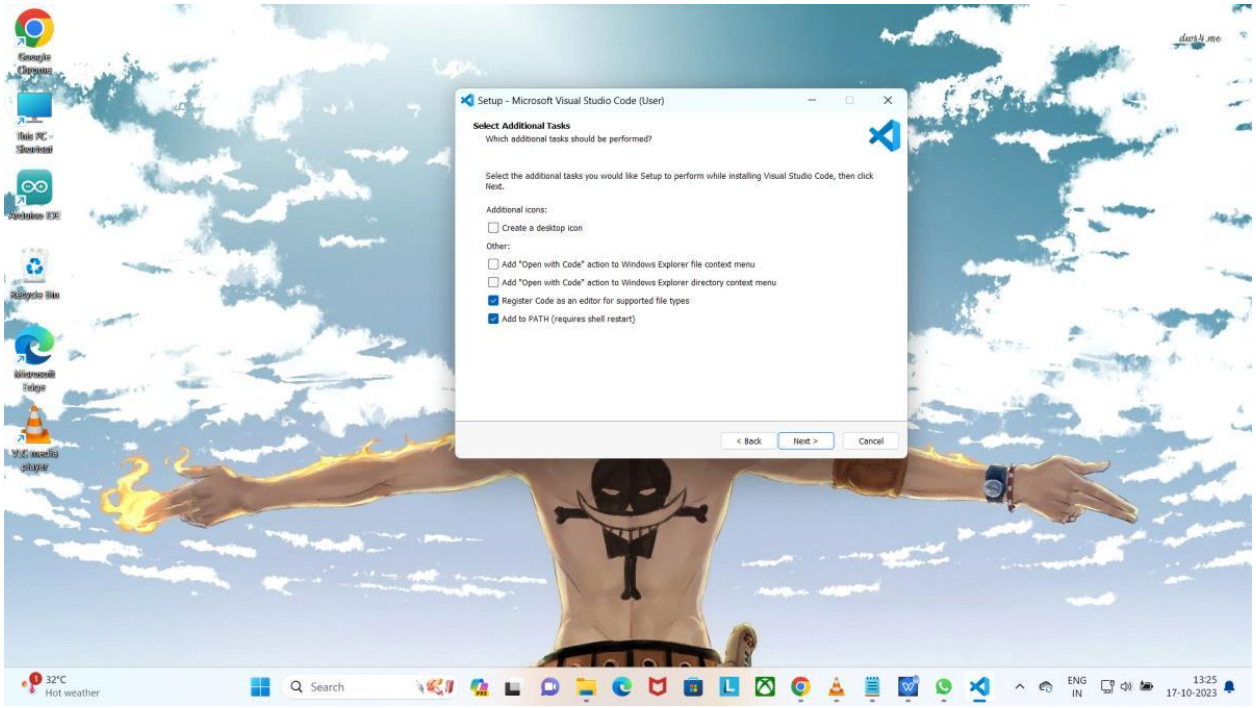


STEP 3: Once it is downloaded, run the installer (VS

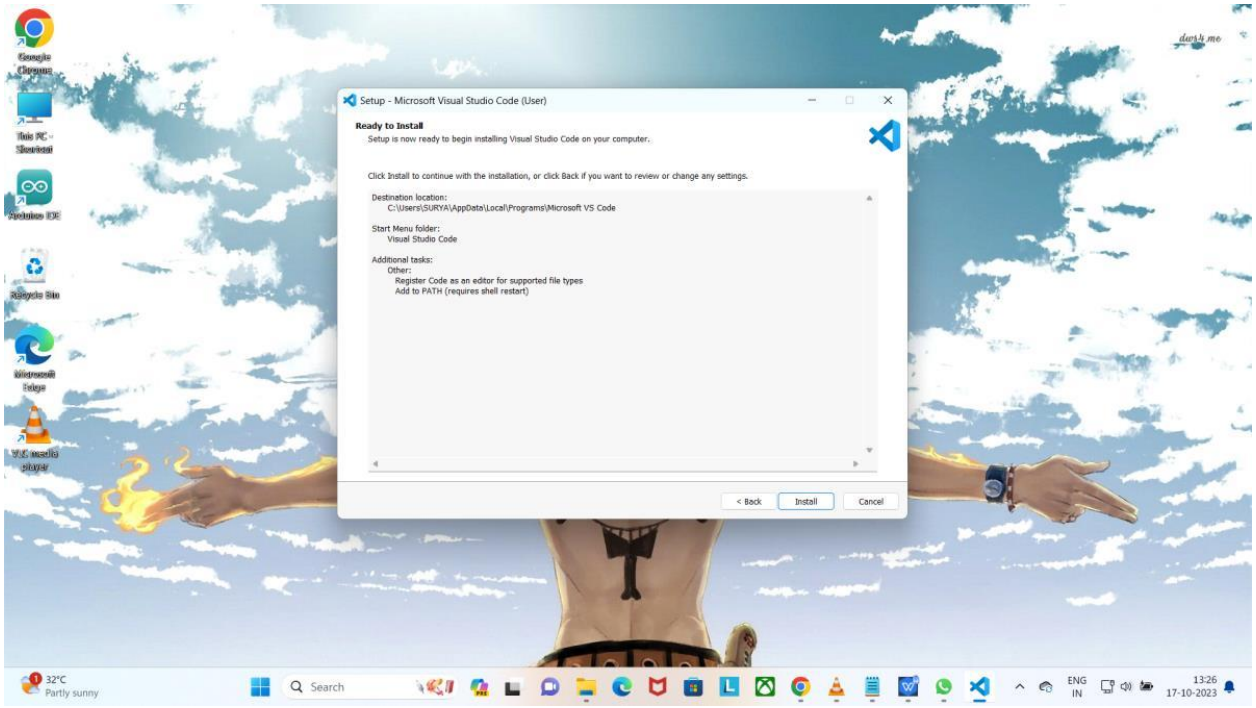


CodeUserSetup-{version}.exe). This will only take a minute.

Step 4: click on NextSTEP

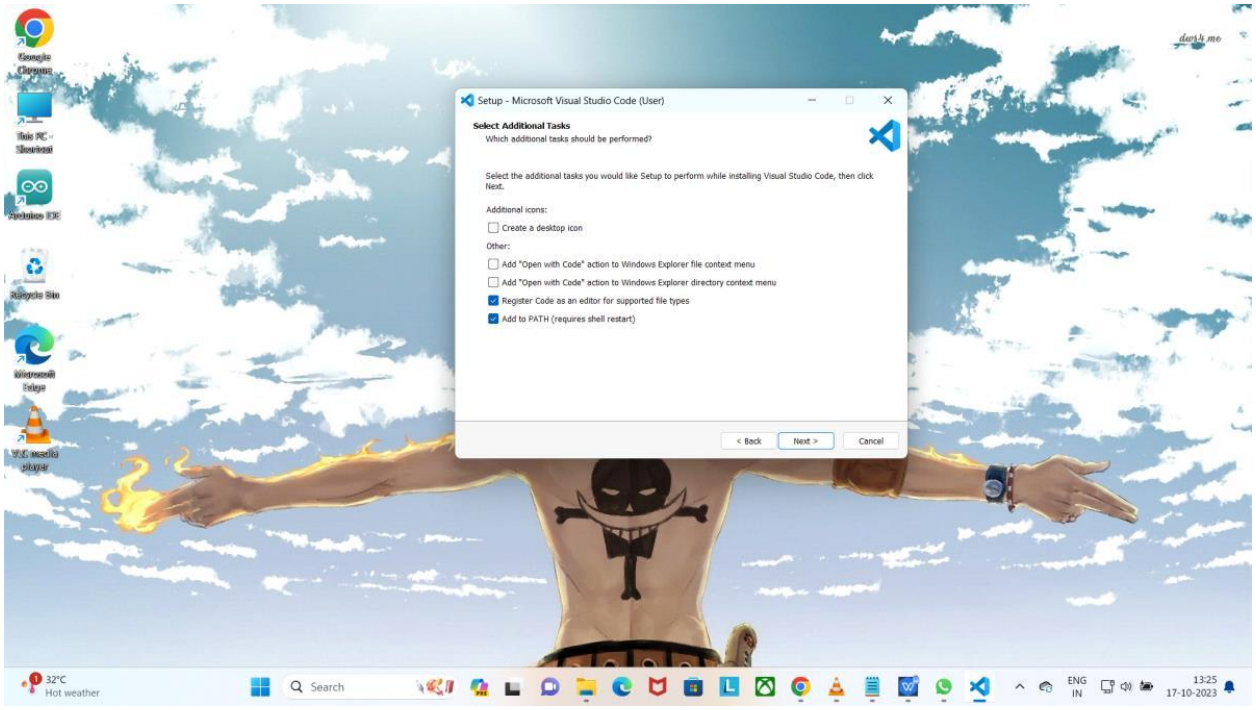


STEP 5: Click on install

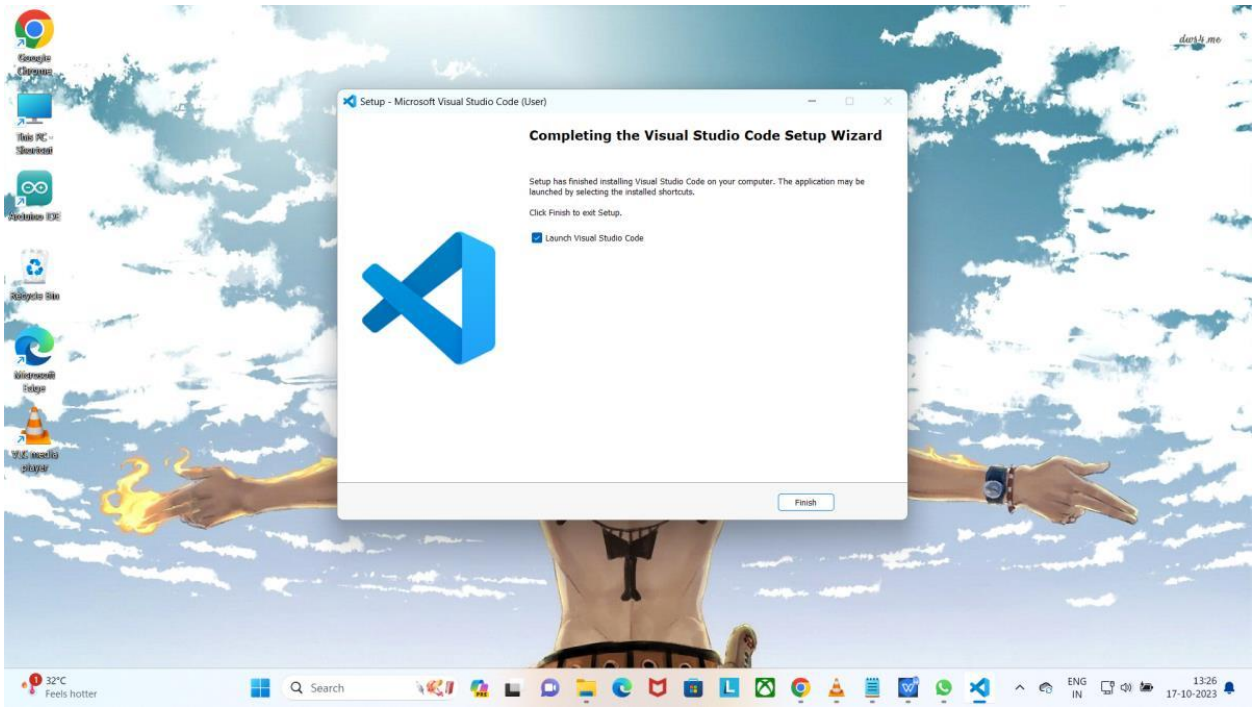


STEP 6: Click on nextSTEP

7: Click on add to pathSTEP

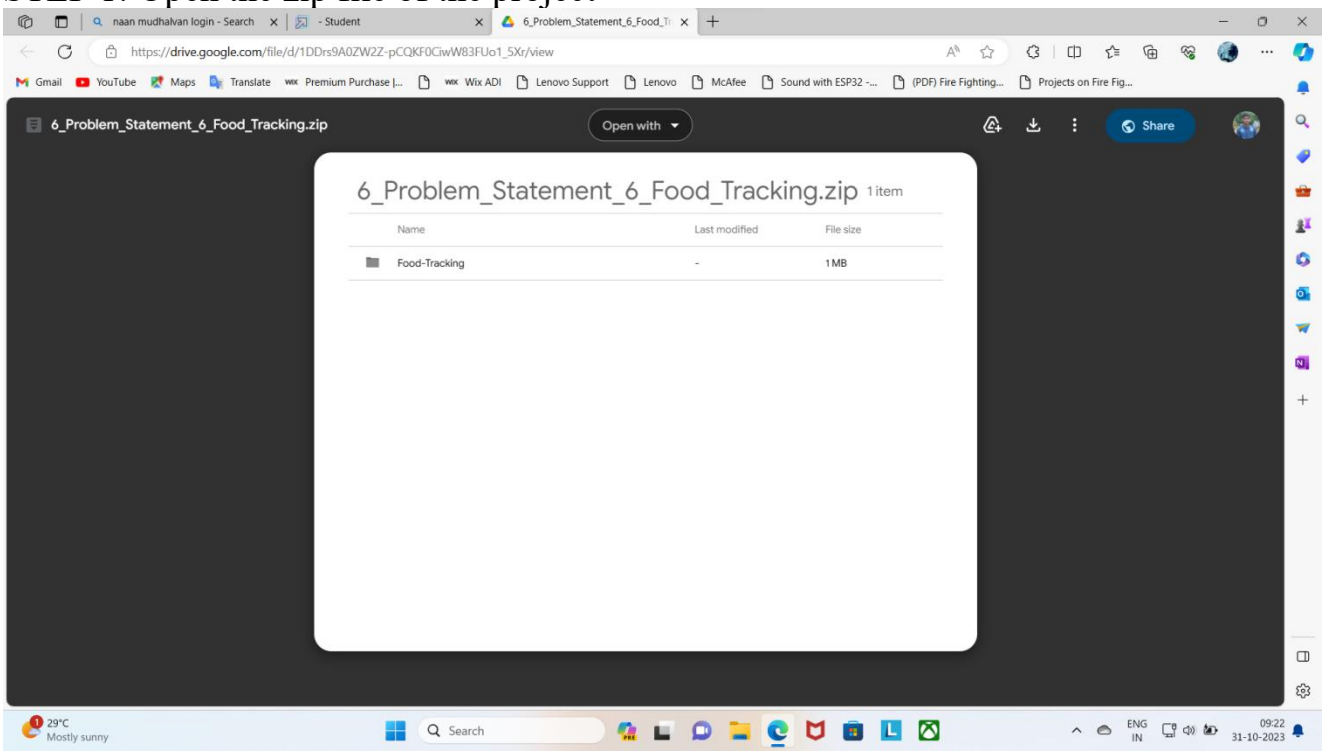


8 : Click on finish

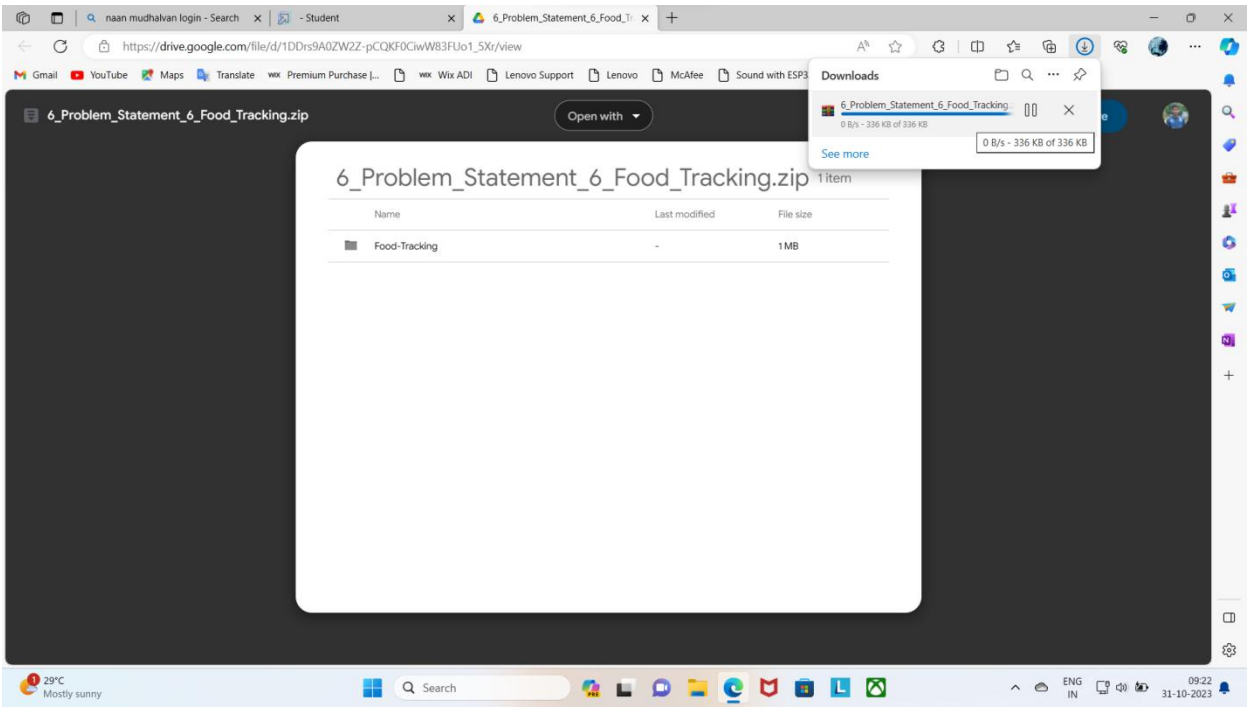


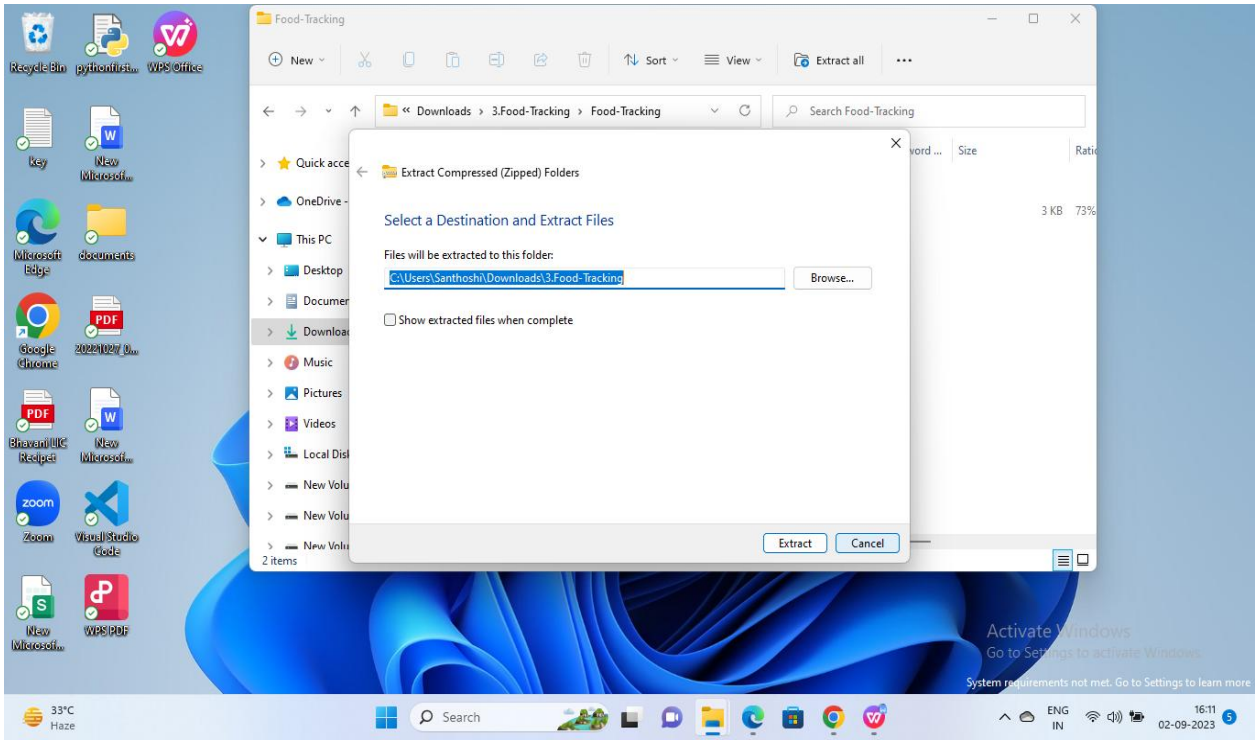
Download The Zip File For The Project And Extract It And Open In VS Code

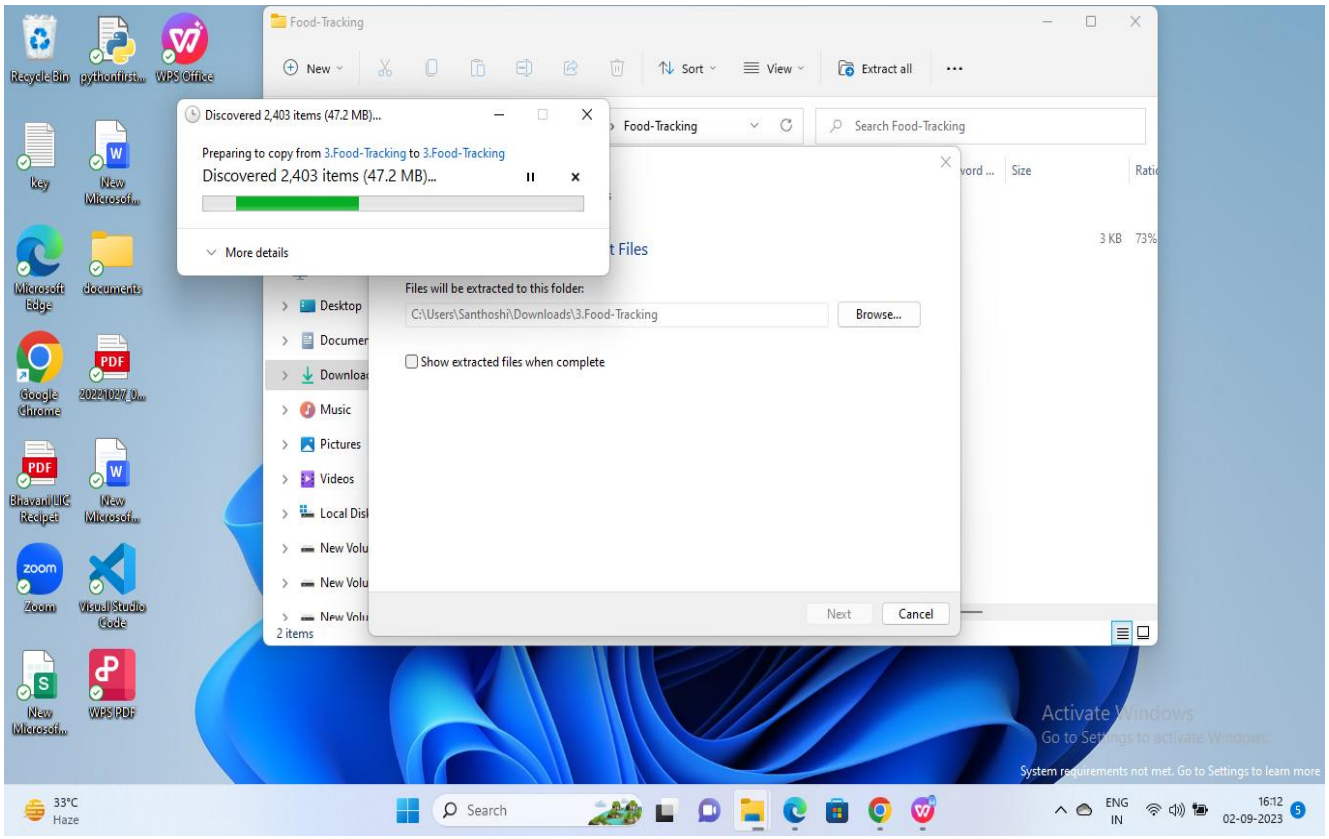
STEP 1: Open the zip file of the project



STEP 2: Extract it and open in VS Code




Food-Tracking
Extract Compressed (Zipped) Folders
Select a Destination and Extract Files
Files will be extracted to this folder:
C:\Users\Santhoshi\Downloads\3.Food-Tracking
Browse...
Show extracted files when complete
Extract
Cancel
Activate Windows
Go to Settings to activate Windows.
System requirements not met. Go to Settings to learn more


Food-Tracking
Discovered 2,403 items (47.2 MB)...
Preparing to copy from 3.Food-Tracking to 3.Food-Tracking
Discovered 2,403 items (47.2 MB)...
More details
Files will be extracted to this folder:
C:\Users\Santhoshi\Downloads\3.Food-Tracking
Browse...
Show extracted files when complete
Next
Cancel
Activate Windows
Go to Settings to activate Windows.
System requirements not met. Go to Settings to learn more

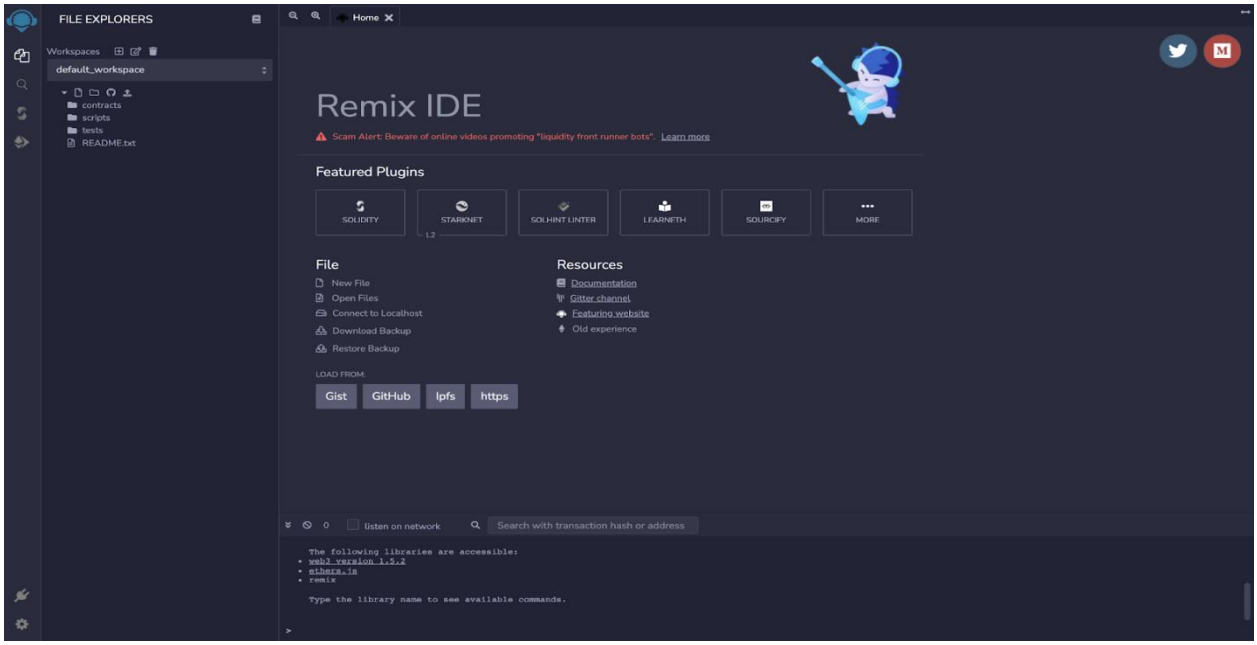
IMPLEMENTATION:

Remix IDE

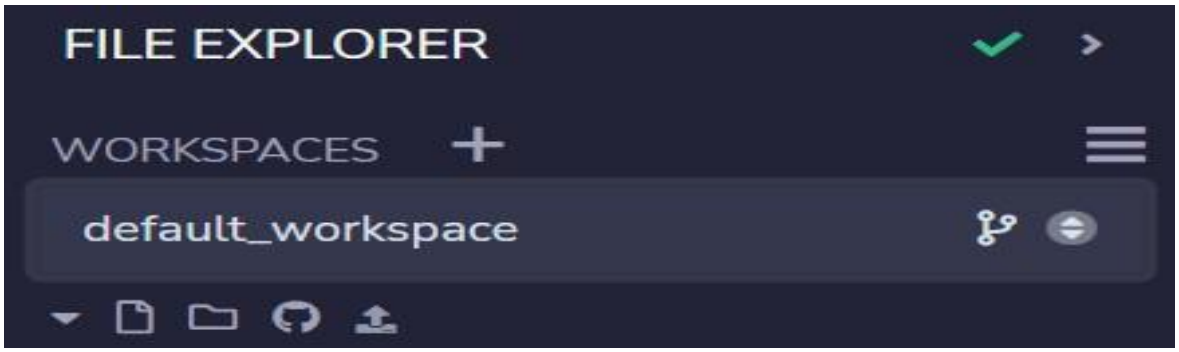
Remix IDE is a no-setup tool with a GUI for developing smart contracts. Used by experts and beginners alike, Remix will get you going in double time. Remix plays well with other tools, and allows for a simple deployment process to the chain of your choice. Remix is famous for its visual debugger.

STEP 1:

- **Open Remix IDE**

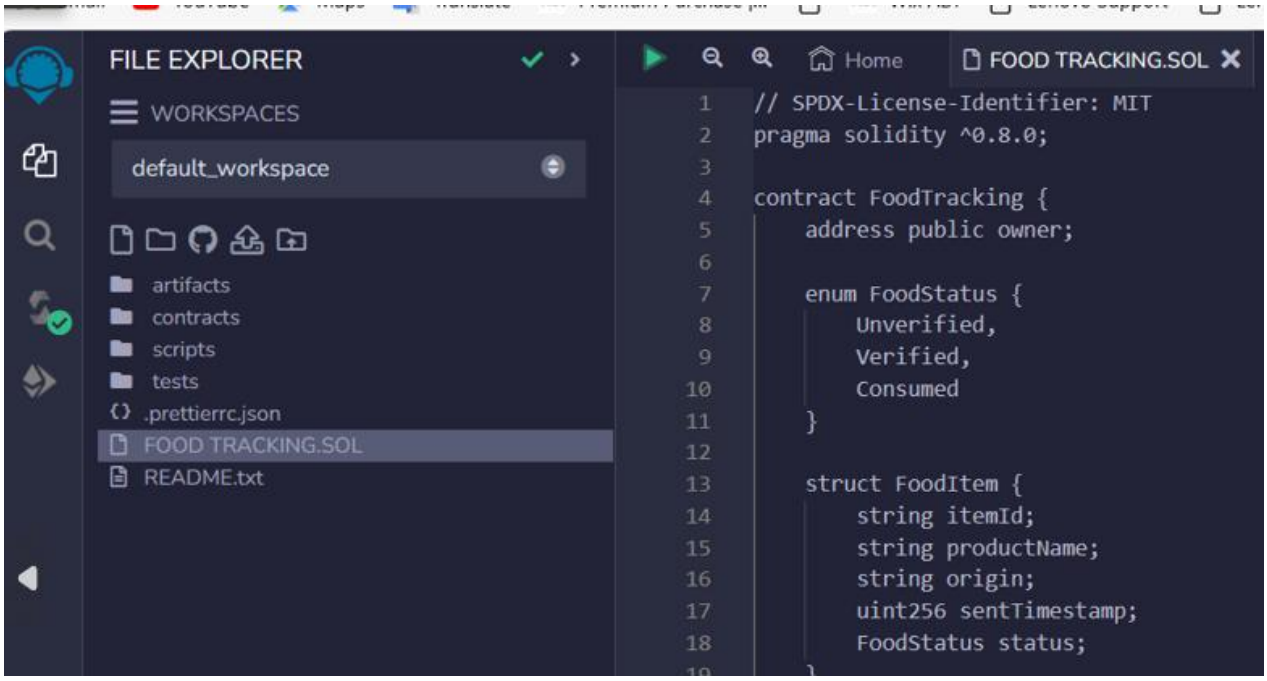


- Click on File Explorers and Create a new WORKSPACE (by Clicking on the + icon).



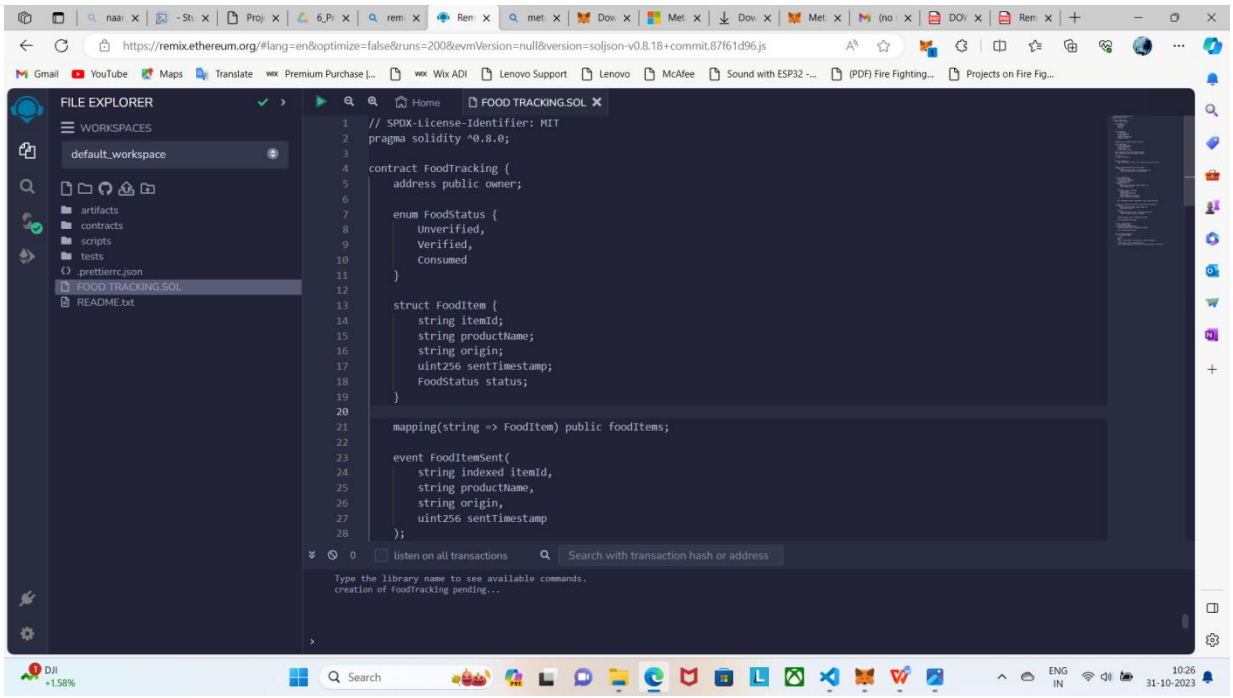
STEP 2:

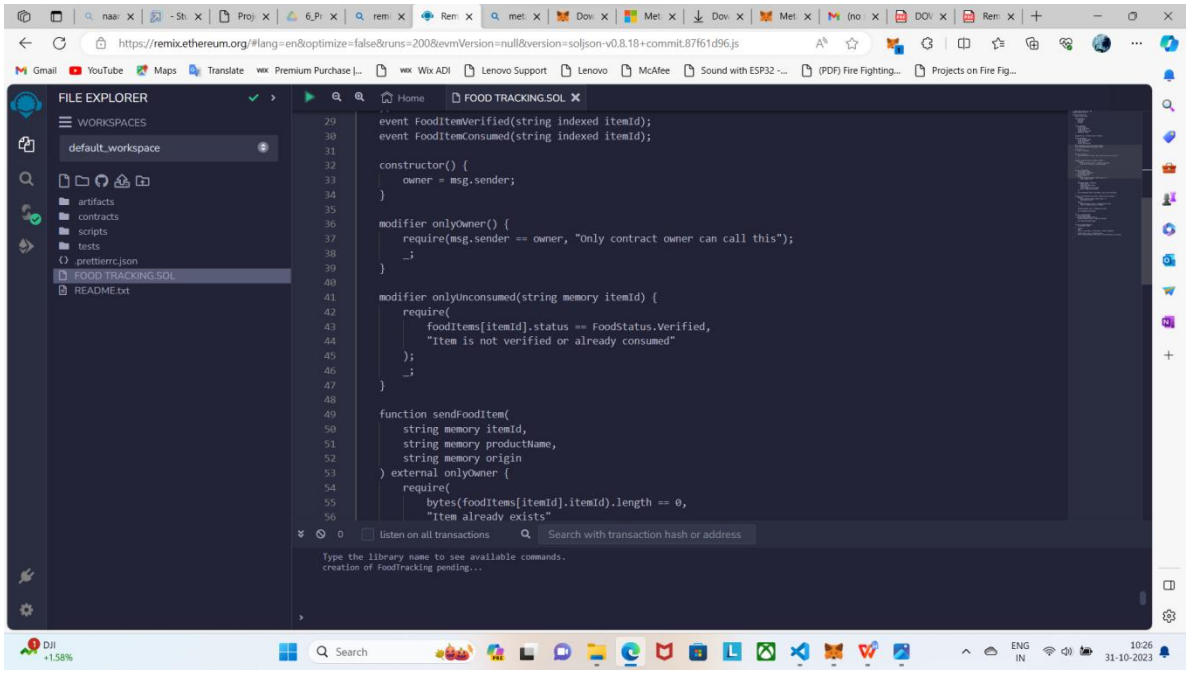
- Click on File Explorers and select Solidity in the environment and create a new file filename.sol by clicking on New File section.



STEP 3:

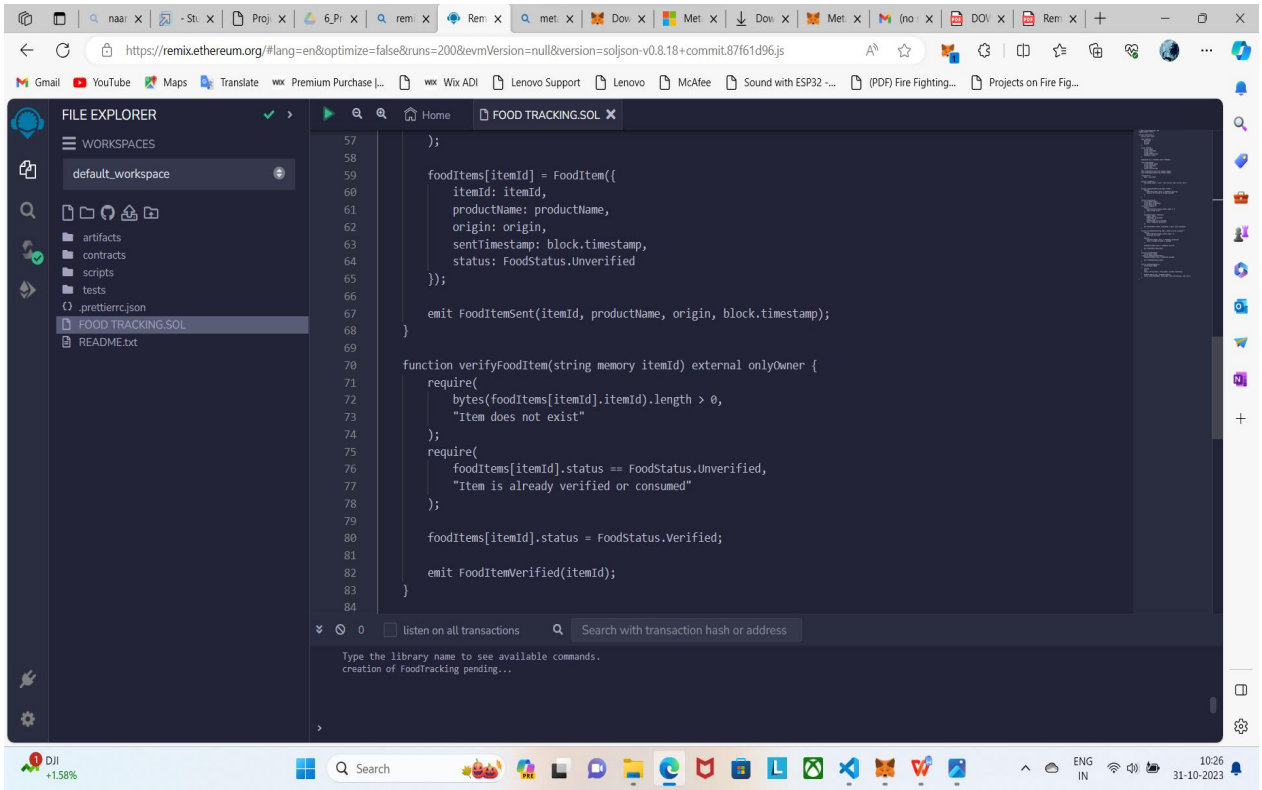
- Add the solidity code in the Filename.sol file.

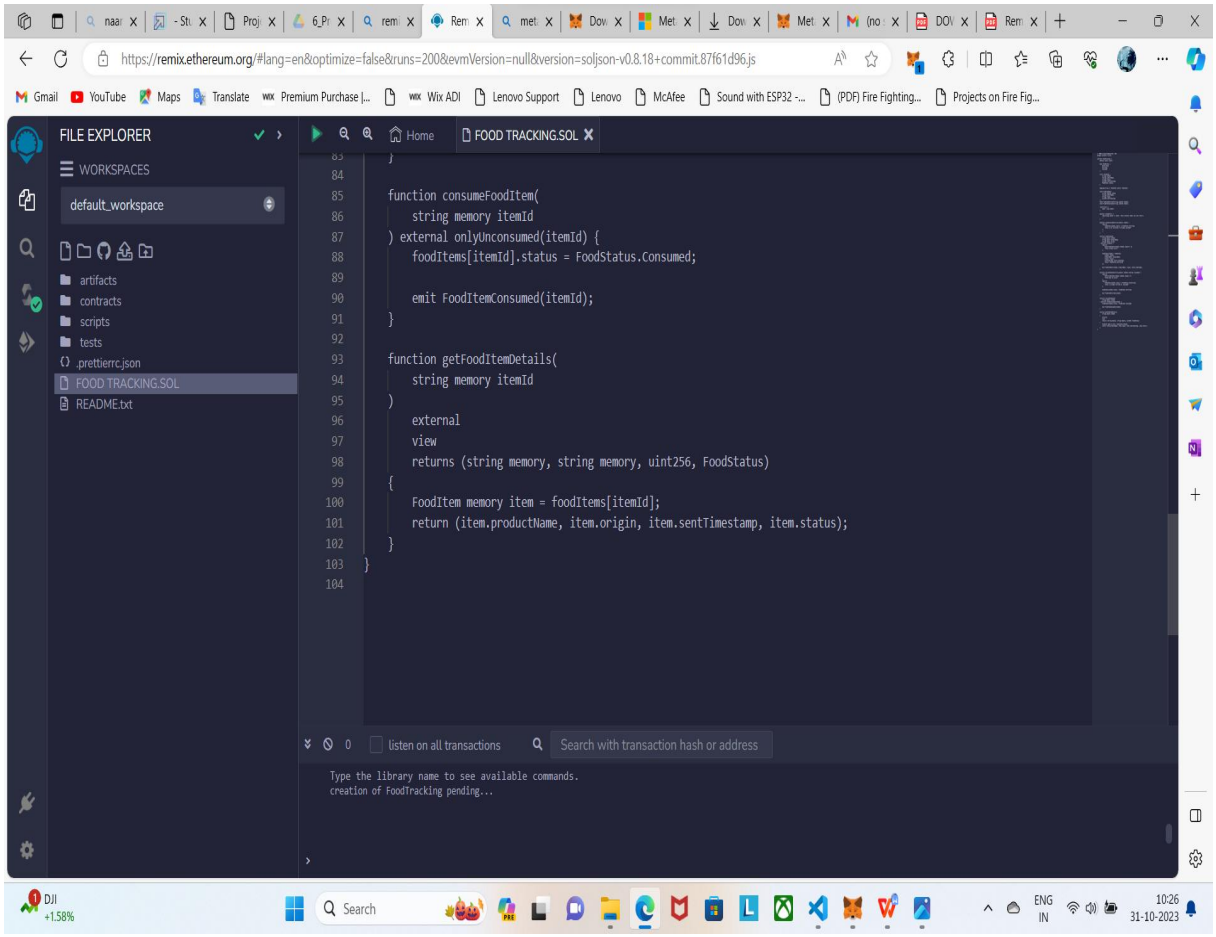




Step 4:

- Create a file in contract folder and paste the smart




FILE EXPLORER
WORKSPACES
default_workspace
artifacts
contracts
scripts
tests
.prettierrc.json
FOOD TRACKING.SOL
README.txt
Home
FOOD TRACKING.SOL
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);
}
}
listen on all transactions
Search with transaction hash or address
Type the library name to see available commands.
creation of FoodTracking pending...
Search
ENG
IN
10:26
31-10-2023

MetaMask Extensions

STEP1 : Open MetaMask by clicking on link : https://metamask.io/

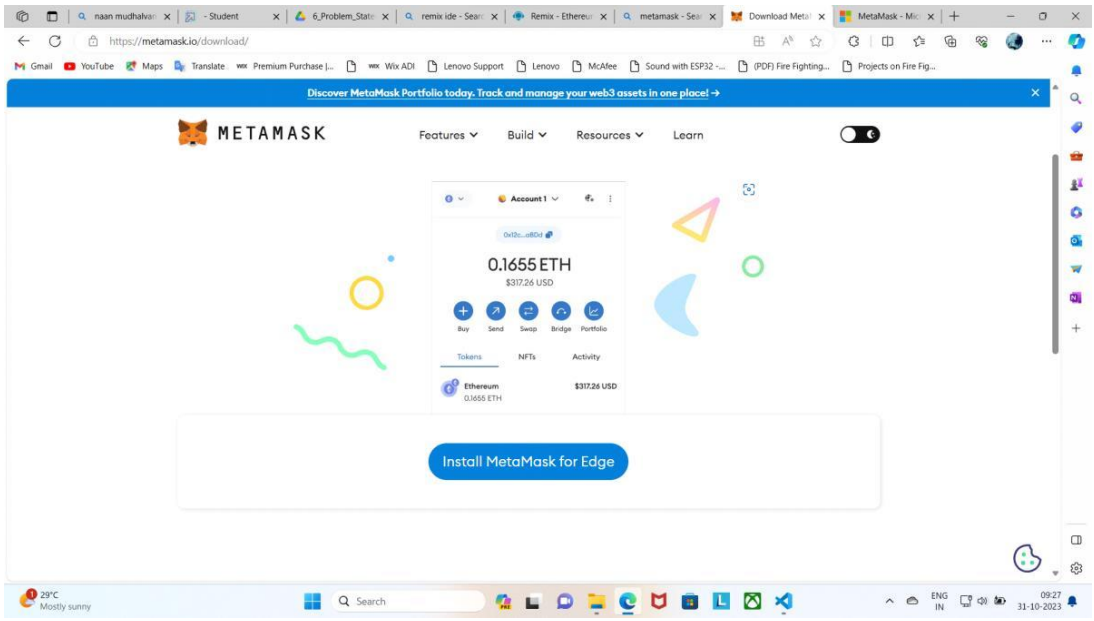
STEP 2 : Click on “Get start” and “ I Agree” and download.

STEP 3:Either click 'Get' or tap on the name of the app to see more details.

Complete the usual App Store download confirmation process.

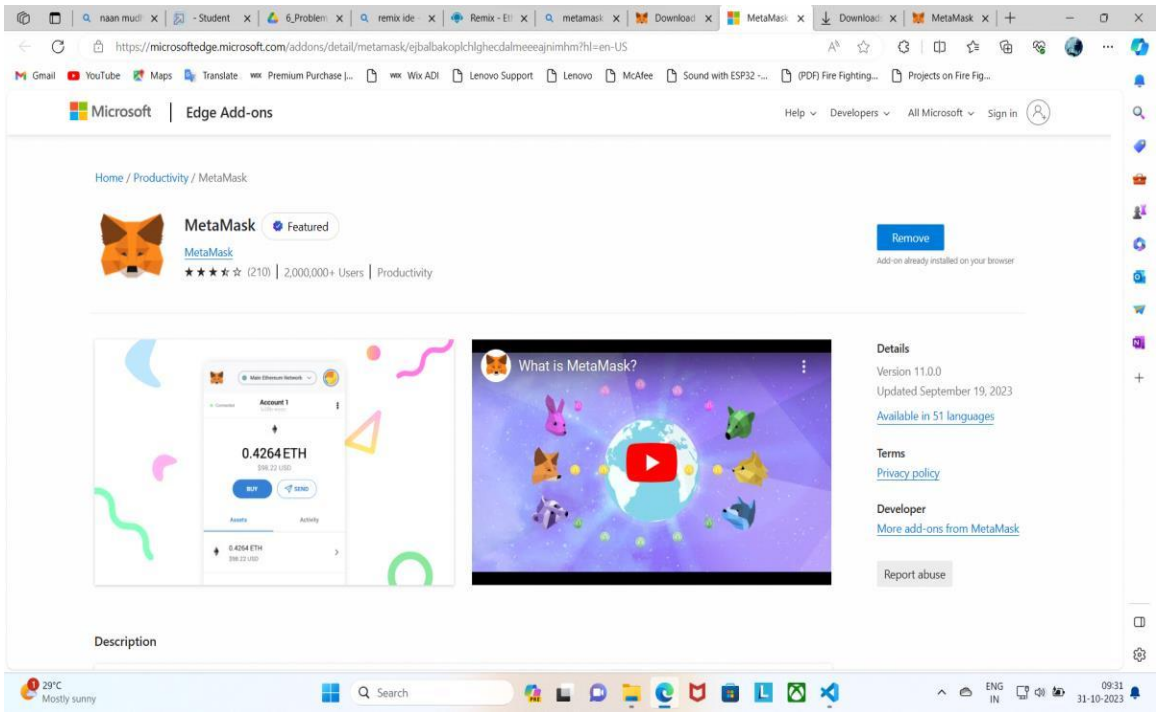
- Once installed, open the app and follow the prompts to create your wallet.
- Back up your Secret Recovery Phrase somewhere safe and offline!
- Create Password and agree to the document.
- Click on next. And relieve
- Copy paste in notepad “all the letters”
- Click on next
- Arrange all the words in the same order as in the notepad.
- Confirm
- All done

Install MetaMask for your browser:

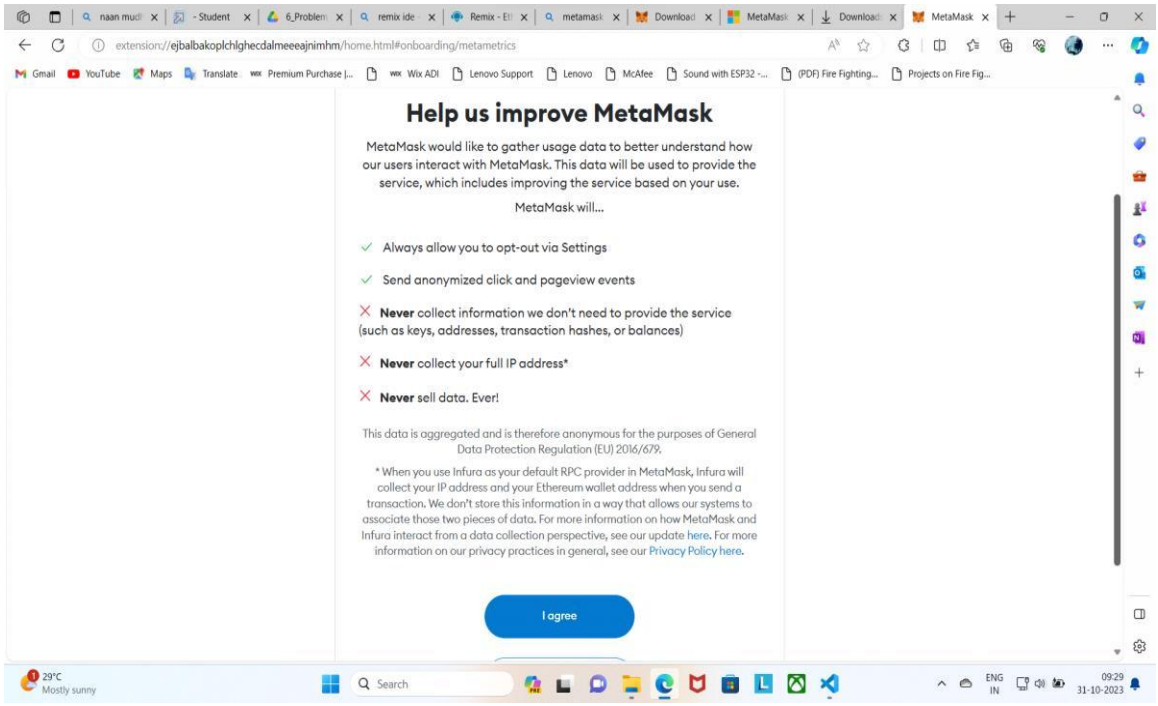


- **Click "Add to Add MetaMask Extension and confirm the pop up. Tap Add**

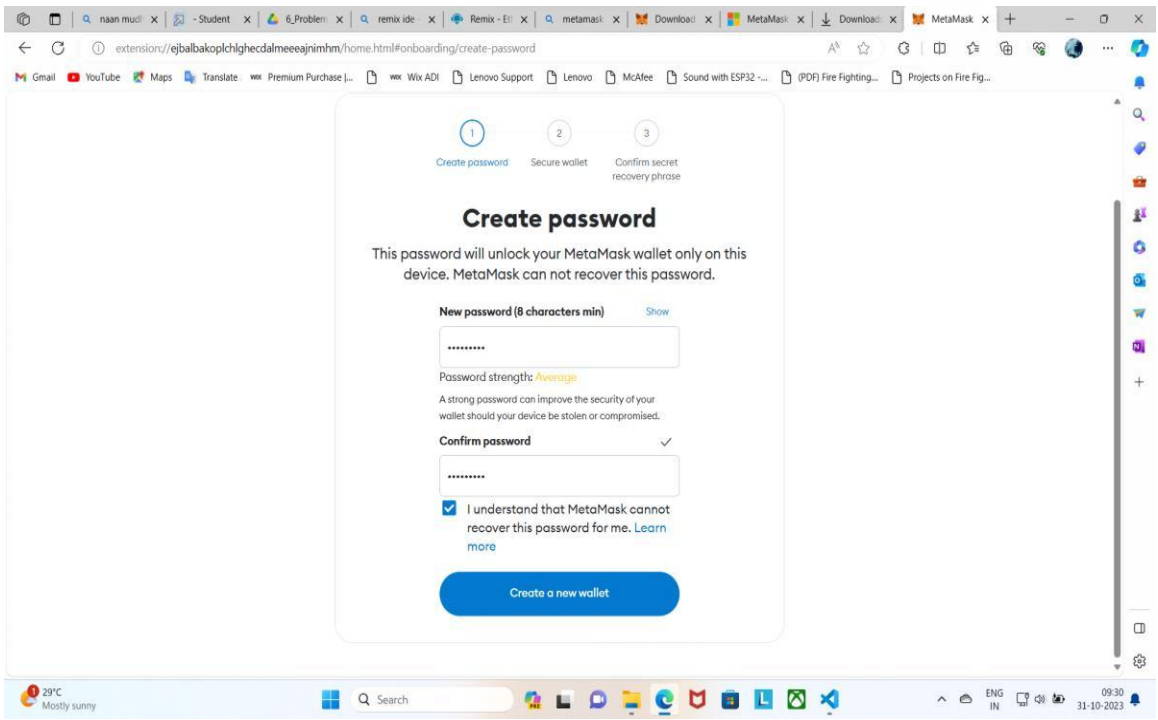
Extension and Click on get started:



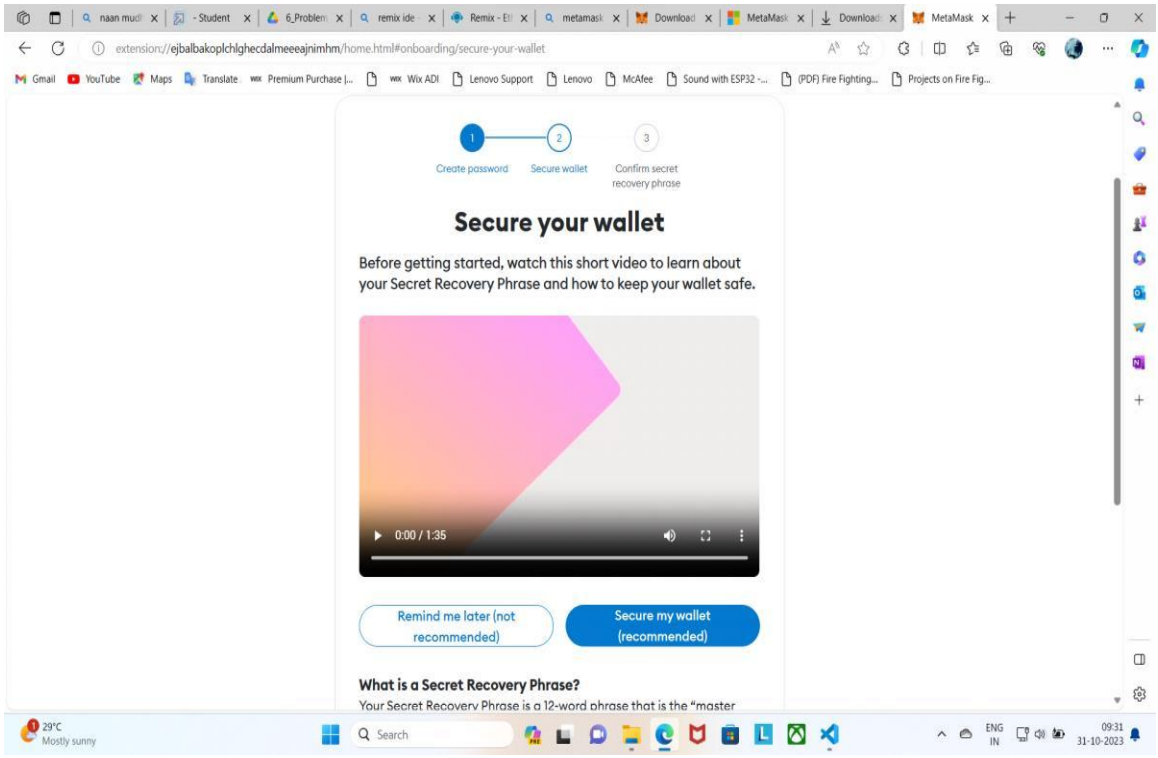
- **Choose Create a Wallet by Clicking on “I Agree”**



- **Click on Create to set up password**

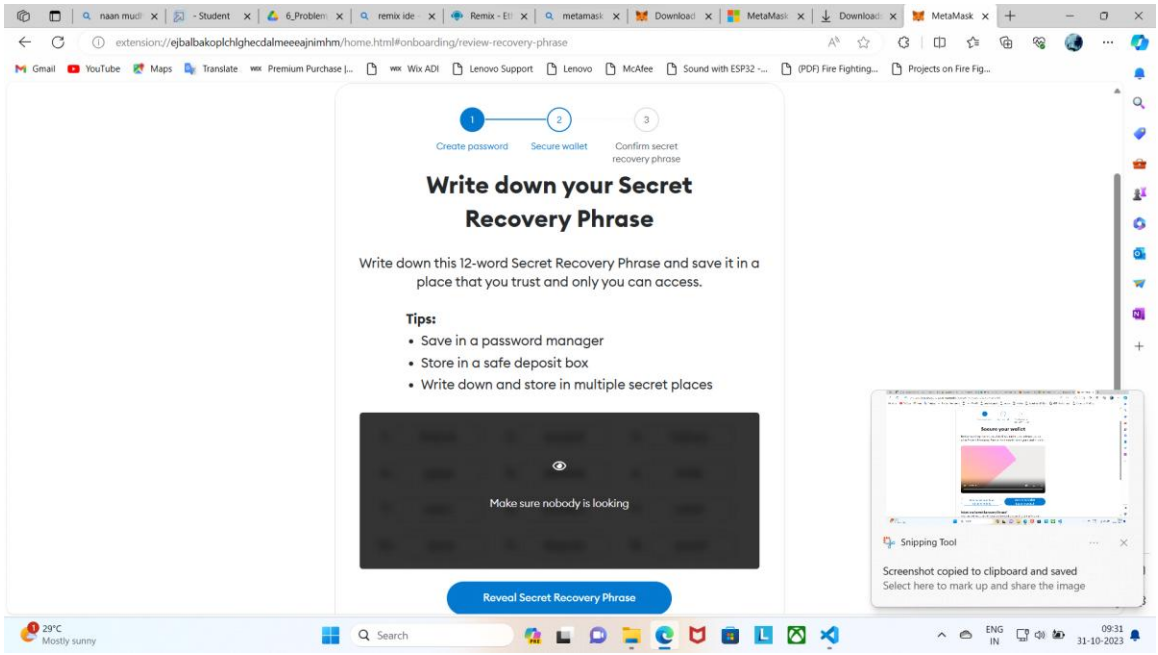


- **Click on Next**

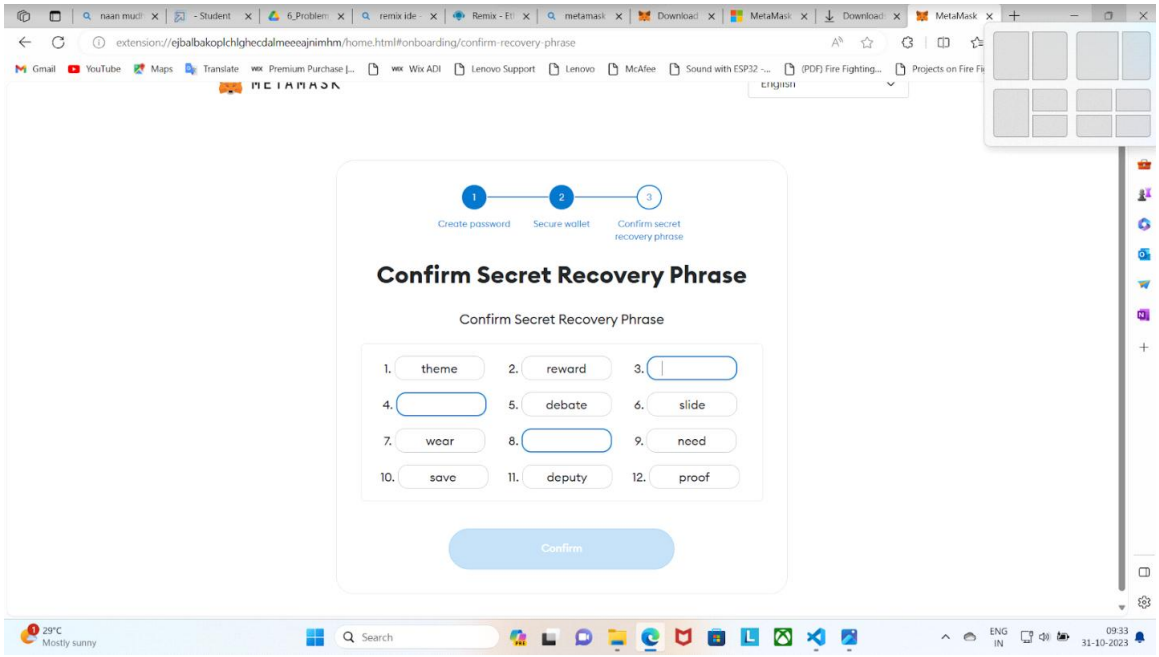


- **IMPORTANT! Tap Click Here to Reveal Secret Words**

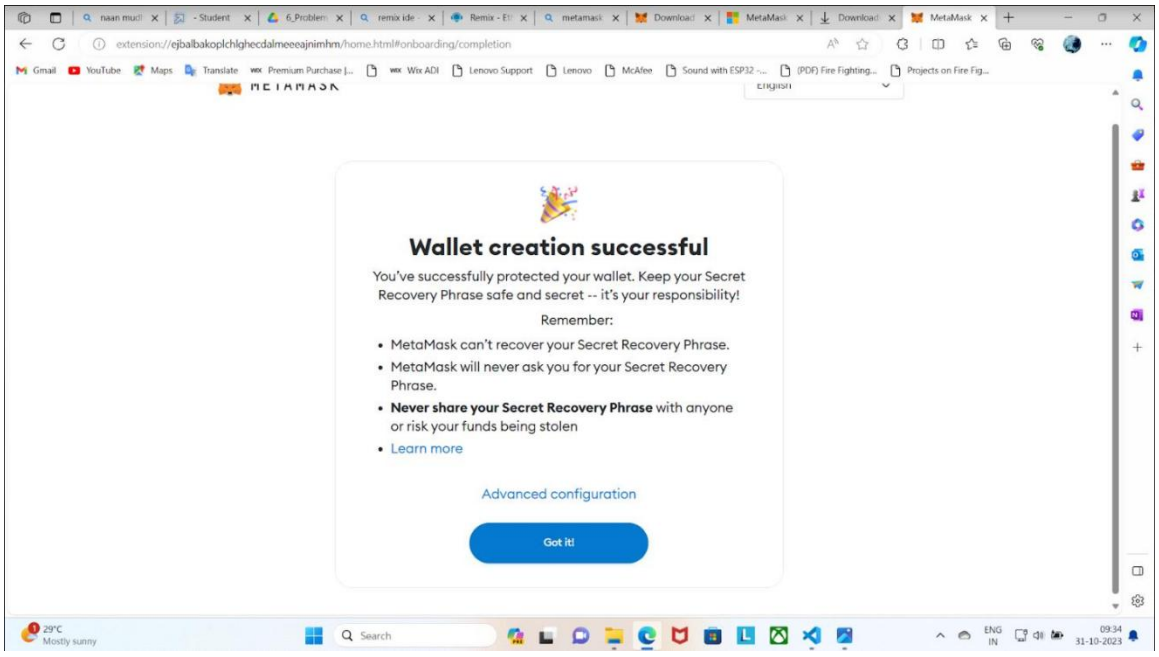
- **Memorize this phase. Write and store it Safely**

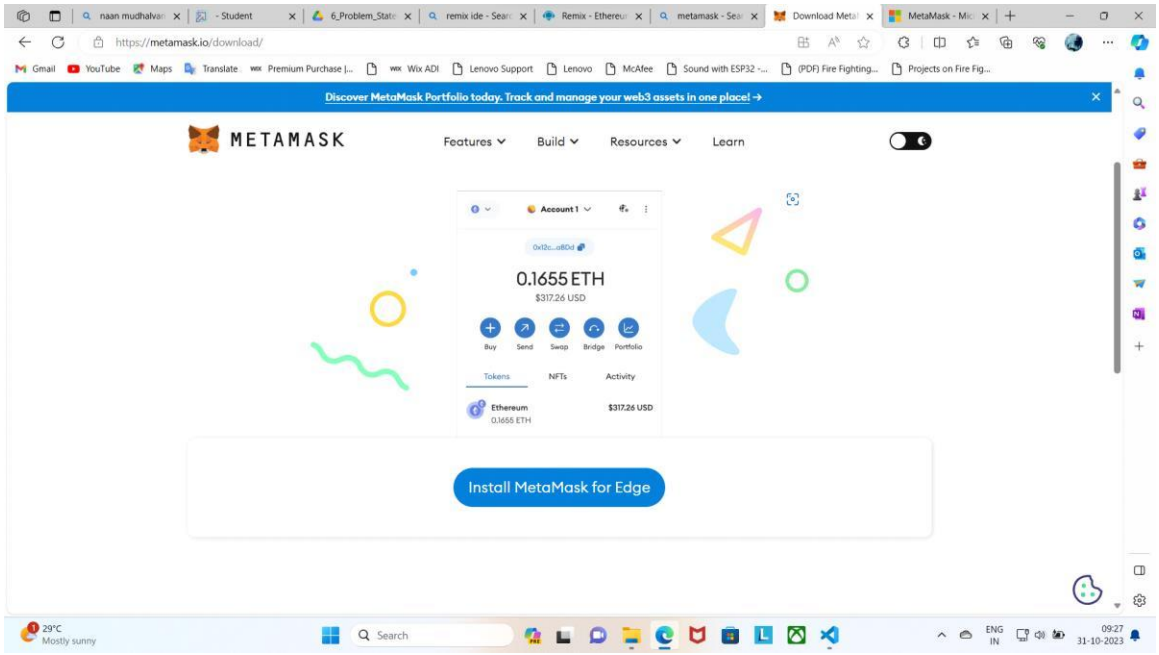


- **Confirm your secret Recovery Phrase by Selecting each phrase in order**
- **Click on confirm to complete the setup**



- **Successfully completed**




https://metamask.io/download/
Discover MetaMask Portfolio today. Track and manage your web3 assets in one place! →
METAMASK
Features
Build
Resources
Learn
Account 1
0.1655 ETH
$317.26 USD
Buy
Send
Swap
Bridge
Portfolio
Tokens
NFTs
Activity
Ethereum
0.1655 ETH
$317.26 USD
Install MetaMask for Edge
29°C
Mostly sunny
Search
ENG
IN
09:27
31-10-2023

FOOD TRACKING SYSTEM

PROGRAM:

```
// 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);
    }
    }
```

CONECTOR CODE

```
const { ethers } = require("ethers");
```

```
const abi = [
 {
  "inputs": [
   {
    "internalType": "string",
    "name": "itemId",
    "type": "string"
   }
  ],
  "name": "consumeFoodItem",
  "outputs": [],
  "stateMutability": "nonpayable",
  "type": "function"
 },
 {
  "inputs": [],
  "stateMutability": "nonpayable",
  "type": "constructor"
 },
 {
  "anonymous": false,
  "inputs": [
   {
    "indexed": true,
    "internalType": "string",
    "name": "itemId",
    "type": "string"
```

```
  }
 ],
 "name": "FoodItemConsumed",
 "type": "event"
},
{
 "anonymous": false,
 "inputs": [
  {
   "indexed": true,
   "internalType": "string",
   "name": "itemId",
   "type": "string"
  },
  {
   "indexed": false,
   "internalType": "string",
   "name": "productName",
   "type": "string"
  },
  {
   "indexed": false,
   "internalType": "string",
   "name": "origin",
   "type": "string"
  },
  {
   "indexed": false,
   "internalType": "uint256",
   "name": "sentTimestamp",
```

```
    "type": "uint256"
   }
  ],
  "name": "FoodItemSent",
  "type": "event"
 },
 {
  "anonymous": false,
  "inputs": [
   {
    "indexed": true,
    "internalType": "string",
    "name": "itemId",
    "type": "string"
   }
  ],
  "name": "FoodItemVerified",
  "type": "event"
 },
 {
  "inputs": [
   {
    "internalType": "string",
    "name": "itemId",
    "type": "string"
   },
   {
    "internalType": "string",
    "name": "productName",
    "type": "string"
```

```
  },
  {
   "internalType": "string",
   "name": "origin",
   "type": "string"
  }
 ],
 "name": "sendFoodItem",
 "outputs": [],
 "stateMutability": "nonpayable",
 "type": "function"
},
{
 "inputs": [
  {
   "internalType": "string",
   "name": "itemId",
   "type": "string"
  }
 ],
 "name": "verifyFoodItem",
 "outputs": [],
 "stateMutability": "nonpayable",
 "type": "function"
},
{
 "inputs": [
  {
   "internalType": "string",
   "name": "",
```

```
  "type": "string"
 }
],
"name": "foodItems",
"outputs": [
 {
  "internalType": "string",
  "name": "itemId",
  "type": "string"
 },
 {
  "internalType": "string",
  "name": "productName",
  "type": "string"
 },
 {
  "internalType": "string",
  "name": "origin",
  "type": "string"
 },
 {
  "internalType": "uint256",
  "name": "sentTimestamp",
  "type": "uint256"
 },
 {
  "internalType": "enum FoodTracking.FoodStatus",
  "name": "status",
  "type": "uint8"
 }
```

```
 ],
 "stateMutability": "view",
 "type": "function"
},
{
 "inputs": [
  {
   "internalType": "string",
   "name": "itemId",
   "type": "string"
  }
 ],
 "name": "getFoodItemDetails",
 "outputs": [
  {
   "internalType": "string",
   "name": "",
   "type": "string"
  },
  {
   "internalType": "string",
   "name": "",
   "type": "string"
  },
  {
   "internalType": "uint256",
   "name": "",
   "type": "uint256"
  },
  {
```

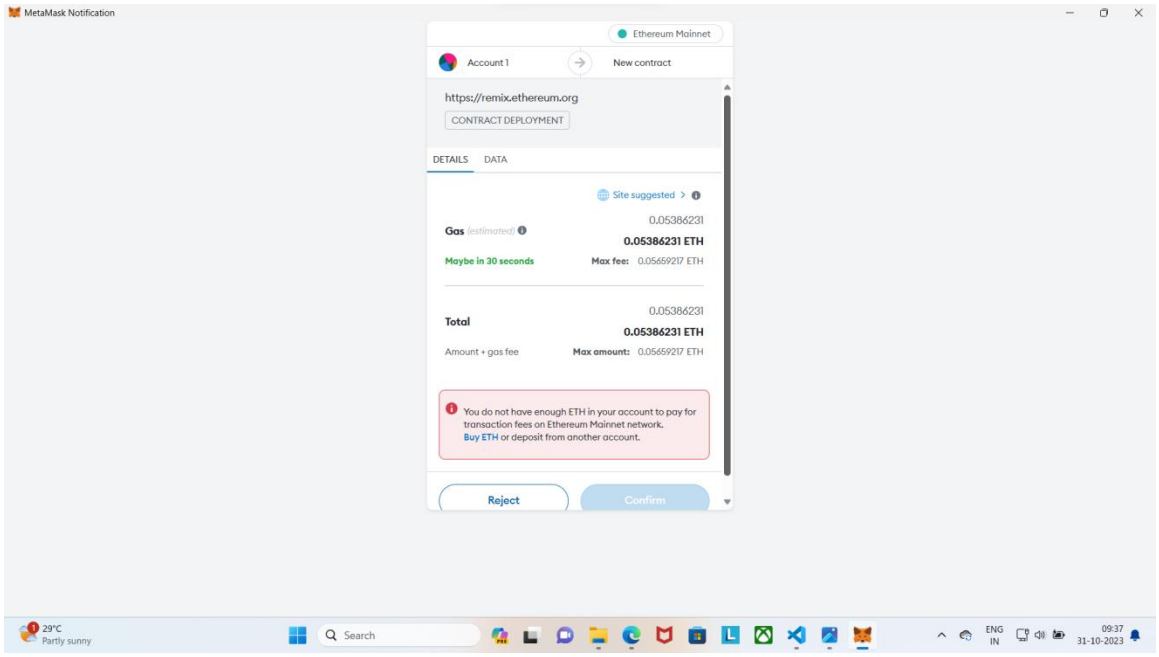
```
    "internalType": "enum FoodTracking.FoodStatus",
    "name": "",
    "type": "uint8"
   }
  ],
  "stateMutability": "view",
  "type": "function"
 },
 {
  "inputs": [],
  "name": "owner",
  "outputs": [
   {
    "internalType": "address",
    "name": "",
    "type": "address"
   }
  ],
  "stateMutability": "view",
  "type": "function"
 }
]
```

```
if (!window.ethereum) {
 alert('Meta Mask Not Found')
 window.open("https://metamask.io/download/")
}
```

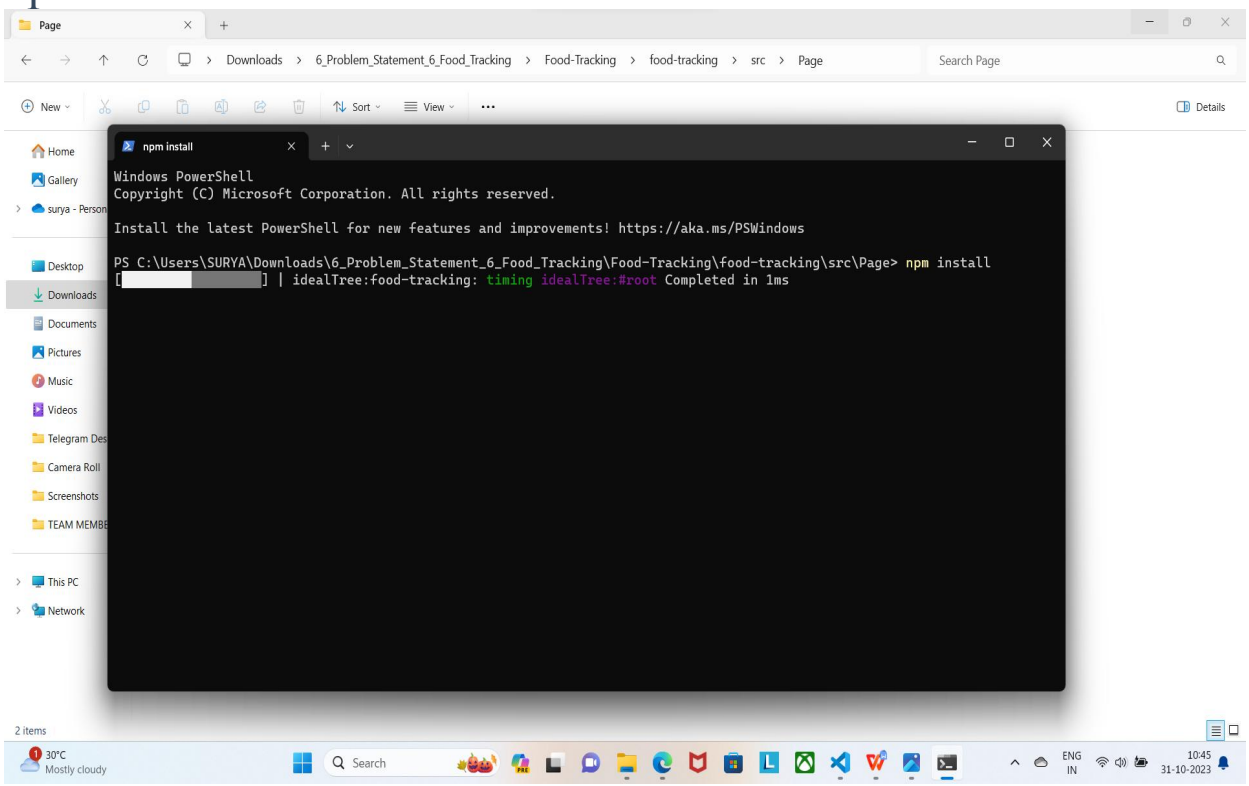
```
export const provider = new ethers.providers.Web3Provider(window.ethereum);
export const signer = provider.getSigner();
```

```
export const address = "0x74EF38843Cc5d2775DcD13577b030A58604e4EFc"
```

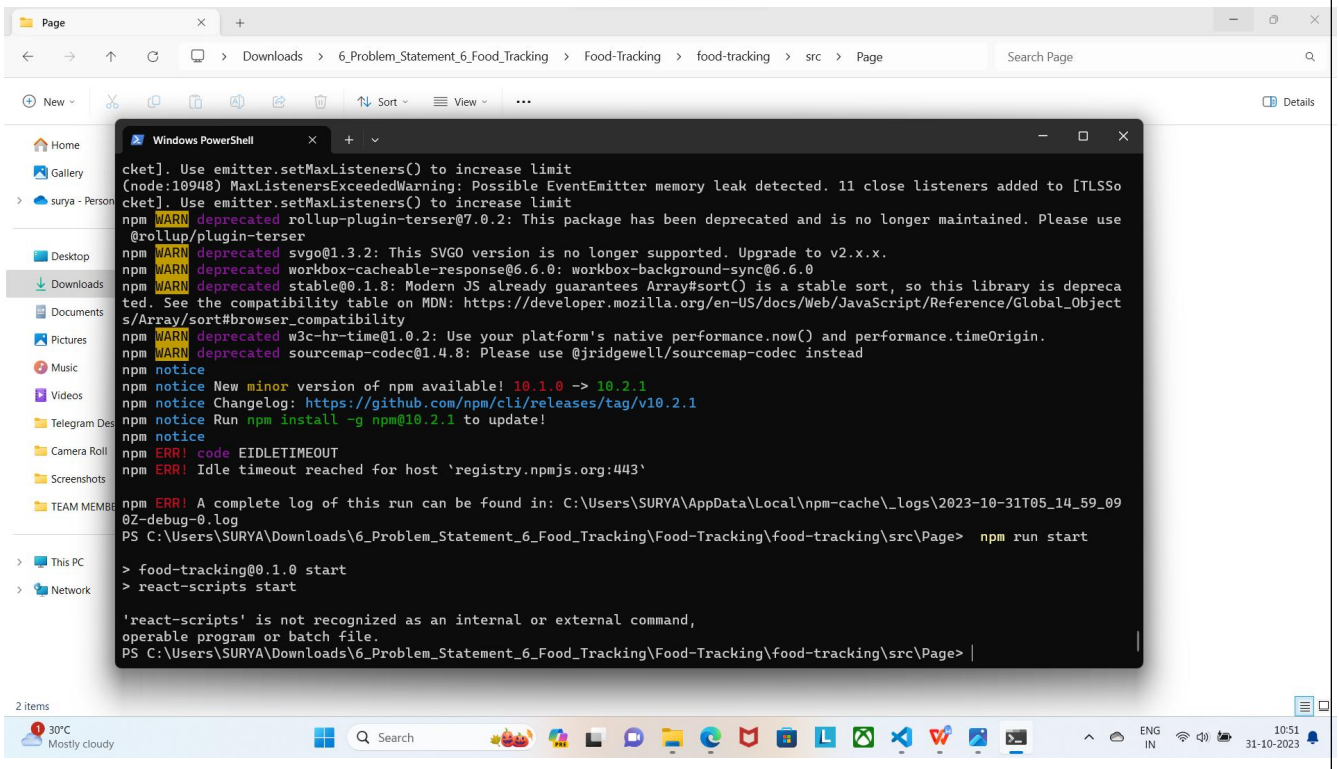
```
export const contract = new ethers.Contract(address, abi, signer)
```



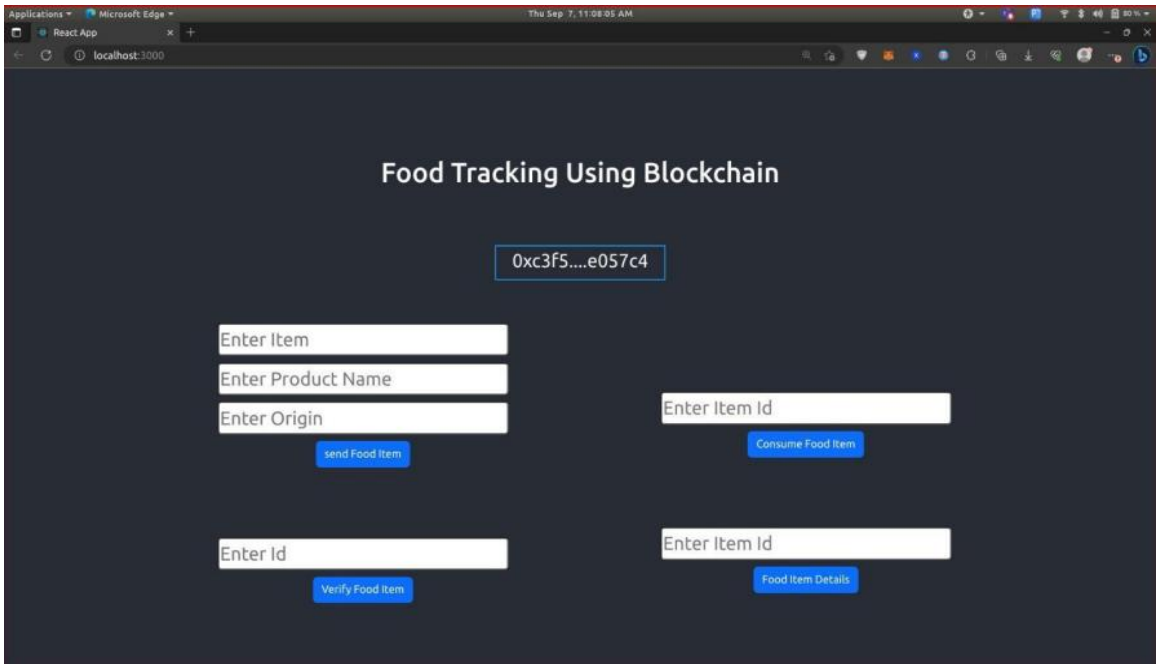
npm install



npm run start



IMPLEMENTATION



ADVANTAGE

Implementing a Food Tracking System using Blockchain offers a multitude of advantages for the food industry. Firstly, it introduces a level of transparency and traceability unparalleled by traditional systems. Through the immutable ledger of blockchain, every step of a food product's journey from farm to table is meticulously recorded and can be readily accessed by stakeholders. This not only builds trust among consumers but also enables swift identification of any contaminated or unsafe products, thus significantly enhancing food safety. Additionally, the technology's tamper-proof nature acts as a powerful deterrent against fraud and counterfeiting, ensuring the authenticity of food products. By streamlining supply chain management through smart contracts and automation, businesses can reduce administrative overhead and paperwork, ultimately leading to greater operational efficiency. Furthermore, compliance with food safety regulations and industry standards is facilitated by the transparent record-keeping capabilities of blockchain. Overall, the adoption of a Food Tracking System using Blockchain is poised to revolutionize the food industry, providing a robust framework for safety, trust, and efficiency in the global food supply chain.

DISADVANTAGE

Despite its numerous benefits, implementing a Food Tracking System using Blockchain comes with its share of challenges. One notable drawback is the complexity of implementation. Integrating blockchain technology into existing systems can be a

daunting task, requiring specialized knowledge and expertise. The process may entail substantial time and resources, particularly for smaller-scale producers or businesses with limited technical capabilities. Additionally, the cost associated with developing and maintaining a blockchain-based system can be a significant barrier, potentially making it less accessible for certain stakeholders. Another concern is the potential scalability issues faced by blockchain networks, particularly on public blockchains, when handling a large volume of transactions. Privacy is also a consideration, as the transparent nature of blockchain means that sensitive information is visible to all participants in the network, raising concerns about data protection.

CONCLUSION

In conclusion, implementing a Food Tracking System using Blockchain represents a significant step forward in revolutionizing the food industry. The advantages it offers, such as unparalleled transparency, enhanced food safety, and trust-building with consumers, have the potential to fundamentally transform the way we track and manage food products. By leveraging the tamper-proof nature of blockchain, the system acts as a robust safeguard against fraud and counterfeiting, ensuring the authenticity of food items. Streamlining supply chain management through automation and smart contracts promises to reduce administrative burdens and increase operational efficiency. Additionally, the technology facilitates compliance with regulatory standards, providing a transparent record of transactions. However, it is essential to acknowledge the challenges, including implementation complexity, cost considerations, scalability issues, and privacy concerns. Navigating the evolving regulatory landscape also presents a potential hurdle.

FUTURE SCOPE

The future scope of a Food Tracking System using Blockchain is promising. Integration with IoT and AI can further enhance real-time monitoring and predictive analytics for the food supply chain. Additionally, the potential for global adoption and the development of industry-wide standards signify a dynamic evolution in food safety and traceability.

APPEDIX

GitHub :https://github.com/surya0701/NM2023TMID01569/tree/main

Project Demo Link:https://youtu.be/kyhFT9ZO3oQ?si=HcNwLV0ozQ2-QDjW