SUPPLY CHAIN MANAGEMENT USING BLOCKCHAIN

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requirements for the award of the
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In

COMPUTER SCIENCE & ENGINEERING

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CERTIFICATE

This is to certify that the Project entitled **"*SUPPLY CHAIN MANAGEMENT SYSTEM USING BLOCKCHAIN*"**, is being submitted by ***P.Sanjana, R.Sanjana, U.Jahnavi, V.Sylvia Anand, Y.Mahalakshmi*** bearing the ***Regd. No. 20B01A05F6, 20B01A05F7, 20B01A05H2, 20B01A05J2, 20B05A05J2*** in fulfillment of the requirements for the award of the degree of " ***Bachelor of Technology*** in ***Computer Science & Engineering***" is a record of bonafide work carried out by her under my guidance and supervision during the academic year **2023 – 2024** and it has been found worthy of acceptance according to the requirements of the university.

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ABSTRACT

The traditional supply chain management is a complex process done manually with insufficient data and without any security in transactions. It includes more time and ineffective processes which may cause customers trouble using this application. To store the details of the transactions and history of the products it will be difficult to enter the data manually and to maintain the records for years is arduous. So, if we include blockchain in this traditional supply chain management then we can increase the efficiency and security of the process. The security in the transactions will be in addition. If we use other technology rather than blockchain, we may get laborious when hacking is involved, because it will be hard to find the hacker. But, with blockchain technology, as security is more, the hacker cannot access the data and no person outside the organization can modify or insert the data. So, if we include blockchain in this traditional supply chain management then we can increase the efficiency and security of the process.

The security in the transactions will be in addition. If we use other technology rather than blockchain, we may get laborious when hacking is involved, because it will be hard to find the hacker. But, with blockchain technology, as security is more, the hacker cannot access the data and no person outside the organization can modify or insert the data. Digitizing physical assets and creating a decentralized, unchangeable record of all transactions are two ways blockchain can help supply organizations manage assets more accurately and transparently from manufacturing to delivery or end-user use. We mainly focus on customers and sellers where the product details will be displayed i.e. when it is manufactured. Because of the details only the security and quality of the product will be known.The objective of integrating blockchain technology into supply chain management is to enhance transparency, traceability, and efficiency across the entire supply chain.

Blockchain can address various challenges in traditional , supply chain systems by providing a decentralized and secure ledger that records transactions and data in a tamper-resistant manner.Blockchain provides a transparent and immutable ledger that allows all participants in the supply chain to have a real-time view of transactions and data. Every transaction or event in the supply chain is recorded in a decentralized and distributed manner, reducing the risk of fraud and errors. Blockchain enables end-to-end traceability of products through the entire supply chain.

Each participant can trace the origin, journey, and handling of products from raw materials to the end consumer.The immutability of blockchain records helps prevent the tampering of product information or the substitution of counterfeit goods. By ensuring that product data is securely stored and easily verifiable, blockchain can significantly reduce the risk of counterfeit products entering the supply chain. Blockchain fosters collaboration among different stakeholders in the supply chain by providing a shared platform for information exchange. Real-time access to accurate data promotes better communication and collaboration between suppliers, manufacturers, distributors, and retailers.

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1. INTRODUCTION

The Owner Module serves as the central control Supply chain management is the movement of goods or products between manufacturers and customers. This flow will follow the process from the core development to the overall development of the product or good. It also includes transporting the product or goods between sources like suppliers, manufacturers, distributors, retailers, customers, etc. As the strategic framework that coordinates the smooth movement of commodities, information, and funds among a network of interrelated entities, supply chain management (SCM) is essential to the modern corporate environment. In today's globalized and highly competitive markets, organizations recognize the critical importance of SCM in enhancing operational resilience, minimizing costs, and optimizing overall performance.

This advancement of the system using blockchain explores the fundamental ideas, new developments, and the revolutionary potential of digital technologies as it digs into the complex dynamics of supply chain management. Through examining the opportunities and problems associated with supply chain management, this research seeks to provide industry and academics with insightful knowledge that will deepen our comprehension of the always-changing nature of supply chain operations

Several connected processes make up the supply chain management process, which makes it easier for products and services to be moved from suppliers to consumers. The procedure entails: Identifying and choosing reliable suppliers based on factors such as quality, cost, and reliability. Establish and maintain strong relationships with suppliers to ensure a smooth flow of materials and information. Negotiate contracts, terms, and conditions with suppliers. Place orders for raw materials or finished goods based on demand forecasts and inventory levels. Convert raw materials into finished goods through manufacturing processes. Optimize production efficiency and quality control measures. Monitor and manage inventory levels to avoid stockouts or excess inventory

.Implement just-in-time (JIT) or other inventory optimization strategies. Plan and execute the transportation of goods from manufacturing facilities to distribution centers. Optimize transportation routes and modes to reduce costs and enhance efficiency. Store and manage inventory in warehouses or distribution centers. Implement efficient warehouse layouts and technology for order fulfillment. Receive and process customer orders.

Communicate order details to the relevant departments for fulfillment. Coordinate the movement of goods from distribution centers to retailers or end customers. Utilize various transportation modes,

including trucks, ships, planes, etc. Manage inventory at retail locations. Ensure that products are appropriately displayed and available for customers. Pick, pack, and ship products to fulfill customer orders.

Provide tracking information and manage returns if necessary. Address customer inquiries, complaints, or issues promptly. Gather feedback to improve processes and enhance customer satisfaction. Handle product returns and manage the reverse flow of goods. Evaluate returned products for possible refurbishment or recycling.

Utilize technologies such as RFID, barcoding, and advanced software systems for real-time tracking and visibility. Implement data analytics for demand forecasting and continuous process improvement. Regularly assess and refine supply chain processes. Adapt to market changes and incorporate new technologies or strategies for increased efficiency.

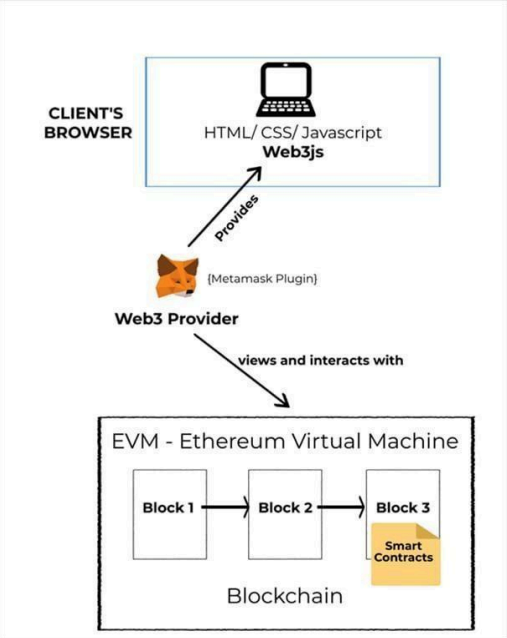


Fig. 1. Working of Ethereum

Blockchain's decentralized control is a paradigm shift from traditional supply chain models. Control is shared among all network members rather than depending on a single entity. This decentralization eliminates single points of failure, enhances resilience, and ensures that the supply chain remains operational even in the face of disruptions.

Improved traceability is another significant advantage of implementing blockchain in supply chain

management. A unique identifier that is recorded on the blockchain can be issued to each product or batch, allowing precise tracing of its path from the point of origin to the point of destination. This traceability is invaluable in identifying the source of issues such as recalls or counterfeit products, allowing for swift corrective actions.Increasing efficiency is a natural outcome of adopting blockchain in supply chain processes.

The streamlined and automated execution of smart contracts within the blockchain network reduces the need for intermediaries, minimizes paperwork, and accelerates transaction times. This efficiency translates to cost savings and quicker response to market demands. Blockchain can help identify and mitigate risks by providing a clear and accurate picture of the entire supply chain. With real-time data and traceability, companies can respond more effectively to disruptions, such as recalls or supply chain interruptions.

Integrating blockchain technology into supply chain management holds the promise of revolutionizing traditional processes, offering a transparent, traceable, and efficient framework. By leveraging the decentralized and tamper-resistant nature of blockchain, supply chain participants can benefit from increased transparency, streamlined operations, and enhanced trust across the entire ecosystem.

The collaborative nature of blockchain technology fosters better communication and collaboration among supply chain participants, creating a more cohesive and responsive network. Ultimately, the integration of blockchain in supply chain management not only addresses current challenges but also sets the stage for a more resilient, agile, and trustworthy supply chain ecosystem.

As industries continue to explore and adopt blockchain solutions, the potential benefits of enhanced transparency, traceability, and efficiency are poised to redefine the future landscape of supply chain management. One significant financial benefit of using blockchain technology in supply chain management is reduced expenses. Blockchain helps to save costs at every stage of the supply chain lifecycle by eliminating the need for middlemen, lowering errors, and improving overall efficiency

.

2. System analysis

System analysis in supply chain management using blockchain involves a comprehensive evaluation of existing processes and the integration of blockchain technology to optimize efficiency and transparency. The analysis encompasses identifying key pain points within the supply chain, assessing data flow, and evaluating the potential benefits of blockchain in addressing specific challenges.

2.1.Existing System:

Traditional supply chain management involves a series of interconnected activities aimed at the production and delivery of goods and services from manufacturers to end consumers. The process typically begins with the procurement of raw materials, followed by manufacturing, distribution, and retail, and ultimately concludes with the delivery of products to customers. In the conventional model, information flow and coordination between.various stakeholders rely heavily on manual processes, often resulting in inefficiencies and challenges.

The procurement stage initiates the supply chain, where organizations source raw materials required for production. This phase involves negotiations with suppliers, order placement, and logistics planning. The manufacturing phase follows, where raw materials are transformed into finished goods. During this stage, production schedules, quality control, and inventory management play crucial roles in ensuring smooth operations.

Once products are manufactured, they move into the distribution phase, involving warehousing, packaging, and transportation. Traditional supply chains often face challenges related to inventory management, as organizations strive to balance the costs of carrying excess inventory against the risk of stockouts. Additionally, the reliance on manual tracking systems can lead to inaccuracies and delays in identifying product locations within the supply chain.

The retail stage involves the sale of products to consumers through various channels such as brick-and-mortar stores or online platforms. Marketing strategies, demand forecasting, and customer relationship management are vital components at this stage. In a traditional supply chain, forecasting accuracy may be limited due to the lack of real-time data, leading to overstocking or understocking issues.

The final stage of the traditional supply chain is the delivery of products to end consumers. Logistics and transportation become critical factors in ensuring timely and cost-effective delivery. Challenges arise in optimizing routes, minimizing transit times, and managing the complexities of last-mile delivery.

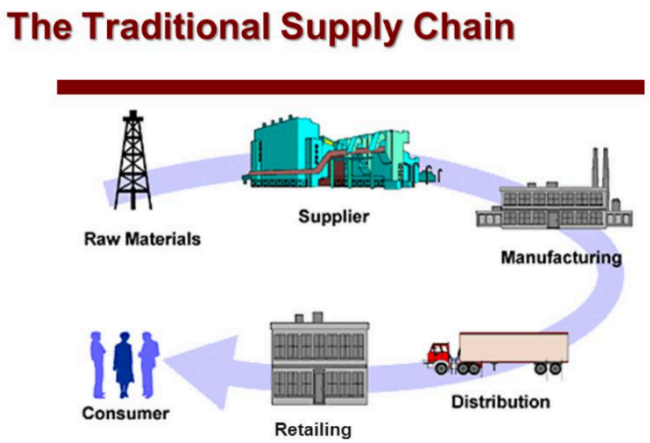


Fig. 2. Traditional Supply Chain Management

Despite its widespread use, traditional supply chain management has several disadvantages. One significant challenge is the lack of real-time visibility into the entire supply chain. Manual data entry and reliance on paper-based documentation make it difficult to track the movement of goods accurately, leading to delays in decision-making and response times. Furthermore, the absence of a centralized data repository often results in information silos among different supply chain partners, hindering collaboration and communication.

Disadvantages of Traditional Supply Chain Management:

1. Lack of Real-Time Visibility:

The traditional supply chain often grapples with a lack of real-time visibility, making it challenging for stakeholders to obtain up-to-date information on the status of products and processes. Manual data entry and paper-based documentation contribute to delays and inaccuracies, hindering the ability to make informed and timely decisions. This limitation can lead to inefficiencies, disruptions, and difficulties in quickly responding to changes in demand or supply chain dynamics.

2. Limited Flexibility and Responsiveness:

Traditional supply chains can be rigid and slow to adapt to changes in market conditions or unforeseen disruptions. The lack of flexibility and responsiveness may result in difficulties in adjusting production

schedules, reallocating resources, or quickly responding to shifts in customer demands. In a rapidly changing business environment, this inflexibility can lead to missed opportunities, increased costs, and challenges in maintaining competitiveness.

3. Inventory Management Challenges:

Balancing optimal inventory levels is a perpetual challenge in traditional supply chain management. Overstocking ties up valuable capital and storage space, while understocking can lead to stockouts and dissatisfied customers. Manual inventory tracking systems and disconnected databases contribute to inaccuracies and inefficiencies in managing stock levels. This can result in increased holding costs, higher chances of stockouts, and challenges in meeting customer demands efficiently..

4. Quality Control Issues:

Traditional supply chains may face difficulties in maintaining stringent quality control standards throughout the entire process. The lack of real-time visibility and traceability can impede the quick identification and resolution of quality issues. This limitation poses risks of defective or substandard products reaching end consumers, potentially damaging brand reputation and customer trust. Quality control challenges may arise from inconsistent processes, manual record-keeping, and difficulties in enforcing standards across the supply chain.

5. Sustainability and Environmental Impact:

Traditional supply chains may not align with modern sustainability goals. Inefficient transportation routes, excess packaging, and overreliance on non-renewable resources contribute to an environmental impact that is increasingly at odds with sustainability objectives.

In conclusion, while traditional supply chain management has been the cornerstone of global trade, it is not without its drawbacks. The limitations in real-time visibility, flexibility, inventory management, quality control, and sustainability have led industries to explore innovative solutions, including the integration of advanced technologies, to address these challenges and propel the supply chain into a more efficient and sustainable future.

2.2.Proposed system:

Supply chain management (SCM) using blockchain is a revolutionary paradigm that leverages decentralized and transparent ledger technology to address challenges inherent in traditional supply chain systems. The foundational concept of blockchain is to create a decentralized and tamper-resistant ledger shared among all participants in the supply chain network. Unlike traditional centralized databases, blockchain ensures that every stakeholder has access to a single version of the truth, reducing errors, fraud, and delays.

This transformative approach enhances traceability and visibility across the entire supply chain. Each transaction is securely recorded, allowing stakeholders to trace the journey of products from origin to the end consumer. This level of transparency is particularly crucial in industries where tracking the provenance of goods is essential, such as food, pharmaceuticals, and luxury goods.

Smart contracts, a core feature of blockchain, automate and enforce predefined contractual agreements in supply chain management. These contracts streamline processes like order fulfillment, payment settlements, and compliance verification, reducing reliance on intermediaries and enhancing overall operational efficiency.

The reduction of counterfeiting and fraud is a significant advantage of blockchain in supply chain management. The decentralized and tamper-resistant nature of blockchain ensures the integrity of product information, allowing participants to authenticate products at every stage. This safeguards consumer trust and protects brands from reputational damage caused by counterfeit goods entering the market.

Improved data security and privacy are critical aspects of blockchain technology. Robust cryptographic techniques secure information stored in the ledger, protecting sensitive data from unauthorized access and tampering. The decentralized architecture further reduces vulnerability, addressing security concerns associated with centralized databases in traditional supply chain systems.

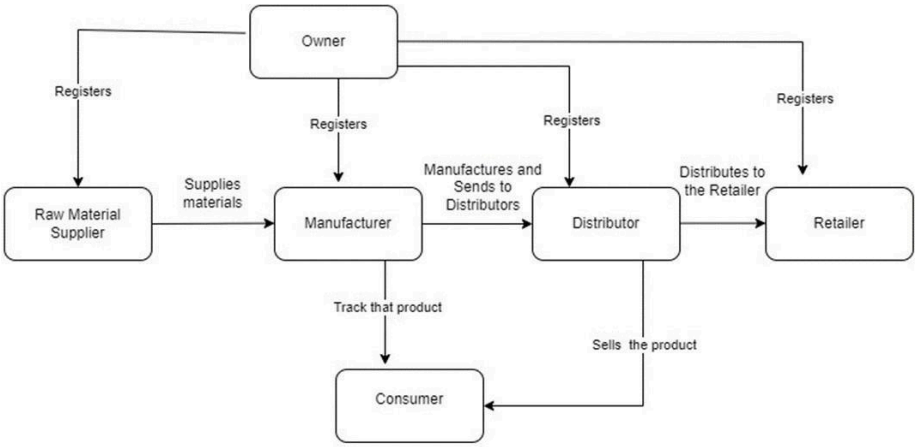


Fig. 3. Architecture diagram

Auditing and compliance verification become more efficient with blockchain integration. The transparent and traceable nature of the ledger simplifies the auditing process, providing auditors with a reliable and immutable record of transactions. This not only reduces the time and resources required for audits but also enhances the accuracy and reliability of compliance assessments.

Real-time access to accurate and up-to-date data is a hallmark of blockchain. Stakeholders can analyze real-time data related to inventory levels, production status, and logistics, enabling more informed decision-making. Real-time analytics enhance overall agility and responsiveness within the supply chain, allowing for proactive responses to changing conditions.

Advantages of Traditional Supply Chain Management:

1. Transparency and Traceability:

Blockchain introduces unprecedented transparency and traceability into supply chain management. Each transaction is securely recorded and time-stamped on a decentralized ledger, providing a clear and immutable history of the product's journey from its origin to the end consumer. This level of transparency ensures that stakeholders can easily trace and verify the authenticity of products, fostering trust among participants and enabling compliance with regulatory requirements.

2. Enhanced Security and Data Integrity:

The decentralized and tamper-resistant nature of blockchain technology significantly enhances the

security and integrity of supply chain data. Traditional supply chains are vulnerable to data manipulation and fraud, but blockchain's cryptographic algorithms make it extremely challenging for unauthorized parties to alter information. This heightened security reduces the risk of counterfeit products, unauthorized access, and data breaches, ensuring the reliability of information throughout the supply chain.

3. Efficiency Through Smart Contracts:

Smart contracts, self-executing contracts with predefined rules and conditions, automate various processes within the supply chain. These contracts facilitate and enforce agreements between parties, such as payment settlements, order fulfillment, and compliance verification. By automating these processes, blockchain streamlines operations, reduces the need for intermediaries, and increases overall efficiency, leading to faster and more cost-effective supply chain management.

4. Real-time Visibility and Decision-making:

Blockchain enables real-time access to accurate and up-to-date information across the supply chain network. Stakeholders can monitor inventory levels, production status, and logistics in real-time, allowing for informed decision-making. The availability of timely data enhances agility and responsiveness, enabling organizations to adapt quickly to changes in demand, supply chain disruptions, or market conditions, ultimately improving overall operational efficiency.

5. Reduction of Counterfeiting and Fraud:

One of the significant advantages of blockchain in supply chain management is the reduction of counterfeiting and fraud. The transparent and tamper-resistant nature of the decentralized ledger ensures the integrity of product information. Participants can verify the authenticity of products at each stage of the supply chain, minimizing the risk of counterfeit goods entering the market. This not only protects consumer trust but also preserves the reputation of brands, contributing to long-term sustainability and success.

Blockchain fosters collaboration, supports ethical practices, and increases resilience to disruptions. As industries continue to adopt and adapt blockchain solutions, the benefits of a more efficient, transparent, and resilient supply chain become increasingly apparent.

2.3.FEASIBILITY STUDY:

The feasibility of the project is analyzed in this phase and a business proposal is put forth with a very general plan for the project and some cost estimates. During system analysis the feasibility study of the proposed system is to be carried out. This is to ensure that the proposed system is not a burden to the company. For feasibility analysis, some understanding of the major requirements for the system is essential accurately, leading to delays in decision-making and response times. Furthermore, the absence of a centralized data repository often results in information silos among different supply chain partners, hindering collaboration and communication.

Three key considerations involved in the feasibility analysis are

- **ECONOMICAL FEASIBILITY**
- **TECHNICAL FEASIBILITY**
- **SOCIAL FEASIBILITY**

Economic feasibility:

.This study is carried out to check the economic impact that the system will have on the organization. The amount of fund that the company can pour into the research and development of the system is limited. The expenditures must be justified. Thus, the developed system as well within the budget and this was achieved because most of the technologies used are freely available. Only the customized products had to be purchased.

Technical feasibility:

This study is carried out to check the technical feasibility, that is, the technical requirements of the system. Any system developed must not have a high demand on the available technical resources. This will lead to high demands on the available technical resources. This will lead to high demands being placed on the client. The developed system must have a modest requirement, as only minimal or null changes are required for implementing this system.

Social feasibility:

The aspect of study is to check the level of acceptance of the system by the user. This includes the

process of training the user to use the system efficiently. The user must not feel threatened by the system, instead must accept it as a necessity. The level of acceptance by the users solely depends on the methods that are employed to educate the user about the system and to make him familiar with it. His level of confidence must be raised so that he is also able to make some constructive criticism, which is welcomed, as he is the final user of the system.

3.System requirements specification

Requirement analysis is a vital step for determining the success of a system or software project.

3.1.SOFTWARE REQUIREMENTS:

Software requirements for a project refer to a comprehensive description of the functionalities, capabilities, constraints, and qualities that a software system must possess in order to meet the needs and expectations of its stakeholders. These requirements serve as the foundation for the design, development, and testing of the software solution. They typically encompass both functional requirements, which describe specific behaviors or functions the software must perform, and non-functional requirements, which define attributes such as performance, security, usability, and reliability.

S/W CONFIGURATION:

1) **Operation system:** Windows 8 or later/ MacOS Sierra 10.12 or later/64-bit Ubuntu 14.04+
2) **Frond end:** Java script, HTML, CSS, React.js
3) **Blockchain Technologies**:

Ganache:

Ganache is used for the overall development of the project. This tool is used to develop the project by giving different scenarios and testing those scenarios whether they are working fine or not. If those test cases are successfully working then we can deploy them directly into the project. This is the main part of the blockchain project where we can create a strong base for the project with different scenarios and test cases useful for the project. This tool is also used for debugging to check the created test cases. Our project contains a separate truffle config file, which is mainly used for the ganache. Based on this file, the ganache will provide the addresses and keys for the people who are involved in developing the product or goods. So, this is the main tool for the application. The developers who are developing the blockchain project should mainly concentrate on the ganache because they are the people who are experimenting with the test cases with different scenarios

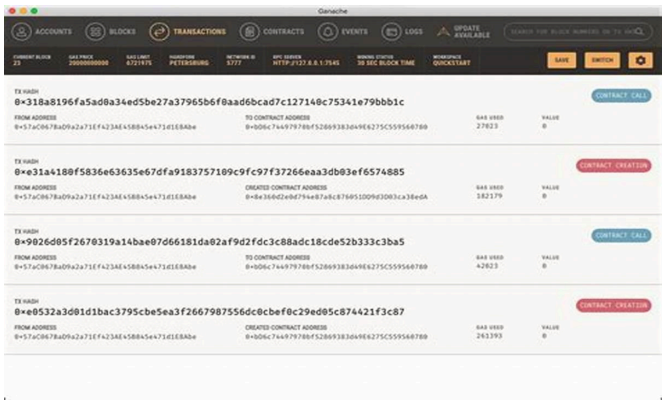


Fig. 4. Ganache

MetaMask:

An addition to the blockchain wallet that handles contracts and transactions is called MetaMask. MetaMask is essential to the field of supply chain management because it allows users to communicate with blockchain apps, particularly those developed on the Ethereum network. We have to add the extension of the metamask to Chrome or other search engines. We have to create an Ethereum project in the metamask. The addresses and private keys created in the ganache are added to the metamask to connect the project. Based on the private keys added, the transactions will occur between the different sources. Finally, the products or goods will reach the customer after all these stages. We can also use other tools which work similar to these. These transactions and contracts will be secure and safe as they can only be restricted to the people who are using the project. They cannot be edited and modified. All the transactions are stored in the cloud or database for verification purposes.This guarantees the transparency and immutability of the recorded data on the Ethereum blockchain in addition to improving supply chain activities' efficiency.

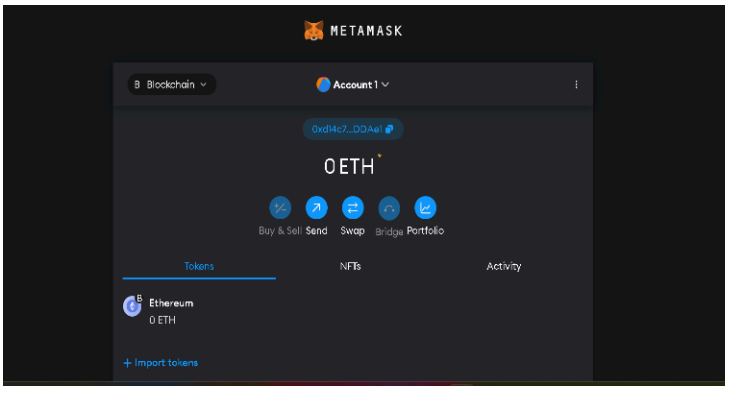


Fig. 5. Metamask

Smart contracts built on Ethereum can be easily integrated into supply chain operations thanks to MetaMask. Order fulfillment, record-keeping, and payment settlement are just a few of the supply chain processes that smart contracts may automate. MetaMask acts as a bridge, enabling users to

interact with these smart contracts through a user-friendly interface.
This guarantees the transparency and immutability of the recorded data on the Ethereum blockchain in addition to improving supply chain activities' efficiency.

Solidity:

Ethereum is one of the most well-known blockchain systems, and Solidity is a high-level programming language made especially for creating smart contracts on these networks. Solidity is essential to supply chain management because it enables smart contracts to automate and carry out business logic. Smart contracts facilitate transparency, immutability, and trust among supply chain participants by enacting terms directly into code and functioning as self-executing agreements.

The development of smart contracts that correspond to different supply chain phases is one method Solidity is applied to supply chain management. One way to use smart contracts is to configure them to run automatically in response to specific events, as when a product is sent, received, or goes through quality control inspections. Because of this automation, there is a decreased need for middlemen, a lower chance of mistakes, and a more secure blockchain record of supply chain activities.

Furthermore, Solidity makes it possible to integrate supply chain elements like transparency and traceability. The blockchain allows for the transparent and unchangeable recording of every event and transaction in the supply chain, making it available to all authorized parties. By improving accountability and lowering the likelihood of fraud or counterfeiting, this transparency aids in tracking the origin, transportation, and status of products. Overall, Solidity's capability to create robust, decentralized, and automated smart contracts makes it a powerful tool for improving efficiency and accountability in supply chain management on blockchain platforms.

This SCM with blockchain can be used by any sector like agriculture, industries, railways, factories, etc. For every sector where the products or goods are developing and selling to the customers, we can use this supply chain process project.

3.2.HARDWARE REQUIREMENTS:

Hardware requirements for a project refer to the specifications and characteristics of the physical components necessary to support and run the software solution effectively. These requirements detail

the minimum and recommended hardware configurations needed for the software to operate optimally, considering factors such as processing power, memory (RAM), storage capacity, network connectivity, and peripheral devices.

H/W CONFIGURATION:

Processor	- I3/Intel Processor
Hard Disk	-160GB
Key Board	- Standard Windows Keyboard
Mouse	- Two or Three Button Mouse
Monitor	- SVGA
RAM	- 4Gb

3.3.Functional and non-functional requirements:

Requirement's analysis is a very critical process that enables the success of a system or software project to be assessed. Requirements are generally split into two types: Functional and nonfunctional requirements.

Functional Requirements:

These are the requirements that the end user specifically demands as basic facilities that the system should offer. All these functionalities need to be necessarily incorporated into the system as a part of the contract. These are represented or stated in the form of input to be given to the system, the operation performed and the output expected. They are basically the requirements stated by the user which one can see directly in the final product, unlike the non-functional requirements.

Examples of functional requirements:

1) Authentication of user whenever he/she logs into the system
2) System shutdown in case of a cyber-attack
3) A verification email is sent to the user whenever he/she registers for the first time on some software system.
4) Functional requirements for a supply chain management system using blockchain typically include:

Transaction Transparency: Ensuring transparency and traceability of transactions across the supply chain.
Immutable Record Keeping: Recording all transactions on the blockchain in an immutable and tamper-proof manner

Smart Contracts: Implementing smart contracts to automate and enforce agreements and transactions between parties.

Interoperability: Ensuring compatibility and seamless data exchange between different participants and systems within the supply chain network.

Identity Management: Managing identities and permissions of participants to ensure secure access and data integrity.

Inventory Tracking: Providing real-time visibility into inventory levels and movements throughout the supply chain.

Quality Control: Implementing mechanisms to track and verify the quality and authenticity of products at various stages of the supply chain.

Compliance Management: Facilitating compliance with regulations and industry standards through automated record-keeping and reporting.

Supplier Management: Managing relationships with suppliers, including sourcing, procurement, and performance tracking.

Risk Management: Identifying and mitigating risks such as fraud, counterfeiting, and disruptions within the supply chain.

Data Security: Ensuring the security and confidentiality of sensitive supply chain data stored on the blockchain.

Analytics and Reporting: Providing analytics tools and reporting capabilities to gain insights into supply chain operations and performance.

Scalability: Designing the system to handle a large volume of transactions and accommodate the growing complexity of the supply chain network.

User Experience: Designing an intuitive user interface for easy interaction with the blockchain-based supply chain management system.

Non-functional requirements:

These are basically the quality constraints that the system must satisfy according to the project contract. The priority or extent to which these factors are implemented varies from one project to another. They are also called non-behavioral requirements.

They basically deal with issues like:

Portability: Portability, as a non-functional requirement, emphasizes the system's ability to seamlessly adapt and operate across various environments, platforms, and devices. It ensures that the software can

be easily transferred and executed in different contexts without compromising functionality or performance. A portable system enhances user flexibility and facilitates widespread accessibility.

Security: Security in non-functional requirements ensures that the system maintains confidentiality, integrity, and availability of data. It involves measures such as encryption, access controls, and robust authentication to safeguard against unauthorized access and data breaches. Emphasizing security as a non-functional requirement helps establish a resilient and protected system infrastructure.

Maintainability: Maintainability in non-functional requirements refers to the ease with which a system can be updated, enhanced, or repaired over time. It involves clear documentation, modular design, and efficient coding practices to ensure long-term sustainability and cost-effective maintenance. Prioritizing maintainability contributes to the system's longevity and adaptability in the evolving technological landscape.

Reliability: Reliability, as a non-functional requirement, emphasizes the system's consistent and dependable performance. It involves ensuring that the software functions reliably under various conditions, minimizing downtime and preventing critical failures. Robustness, fault tolerance, and consistent availability are key aspects addressed to meet the reliability criteria in software development.

Scalability: Scalability, a crucial non-functional requirement, ensures a system's ability to handle increased load efficiently. It focuses on accommodating growing user demands without compromising performance or stability. Robust scalability ensures that a system can seamlessly expand its capacity, making it adaptable to evolving requirements and user base.

Performance: Performance in non-functional requirements focuses on the system's efficiency, responsiveness, and scalability. It addresses factors like response times, throughput, and resource utilization, ensuring optimal functionality under varying workloads. Emphasizing performance helps deliver a reliable and high-performing system for end-users.

Reusability: Reusability in non-functional requirements involves designing system attributes that can be applied across various contexts without modification. This enhances efficiency by allowing components or specifications to be reused in different projects, promoting consistency, and reducing development effort. Incorporating reusability in non-functional aspects contributes to a more adaptable and scalable software architecture.

Flexibility: Flexibility in non-functional requirements refers to the system's ability to adapt and scale easily in response to changing conditions or demands. This includes accommodating variations in user load, integrating new functionalities seamlessly, and adjusting to evolving technological landscapes. A flexible system enhances long-term sustainability and responsiveness to dynamic business or user

needs.

Examples of non-functional requirements:

1) Emails should be sent with a latency of no greater than 12 hours from such an activity.
2) The processing of each request should be done within 10 seconds
3) The site should load in 3 seconds whenever of simultaneous users are > 10000

4. System design

4.1.Introduction:

System design for a project involves the process of defining the architecture, components, modules, interfaces, and data flow of a software system to meet the specified requirements. It is a crucial phase in the software development lifecycle where high-level requirements are translated into a detailed design that serves as a blueprint for implementation.

Input Design:

In an information system, input is the raw data that is processed to produce output. During the input design, the developers must consider the input devices such as PC, MICR, OMR, etc.

Therefore, the quality of system input determines the quality of system output. Well-designed input forms and screens have following properties

- It should serve a specific purpose effectively such as storing, recording, and retrieving the information.
- It ensures proper completion with accuracy.
- It should be easy to fill and straightforward.
- It should focus on the user's attention, consistency, and simplicity.
- All these objectives are obtained using the knowledge of basic design principles regarding
    - What are the inputs needed for the system?
    - How end users respond to different elements of forms and screens.

Objectives for Input Design:

The objectives of input design are −

- To design data entry and input procedures
- To reduce input volume
- To design source documents for data capture or devise other data capture methods
- To design input data records, data entry screens, user interface screens, etc.
- To use validation checks and develop effective input controls.

Output Design:

The design of output is the most important task of any system. During output design, developers

identify the type of outputs needed, and consider the necessary output controls and prototype report layouts.

Objectives of Output Design:

The objectives of input design are:

- To develop output design that serves the intended purpose and eliminates the production of unwanted output.
- To develop the output design that meets the end user's requirements.
- To deliver the appropriate quantity of output.
- To form the output in appropriate format and direct it to the right person.
- To make the output available on time for making good decisions.

4.2.DATA FLOW DIAGRAMS:

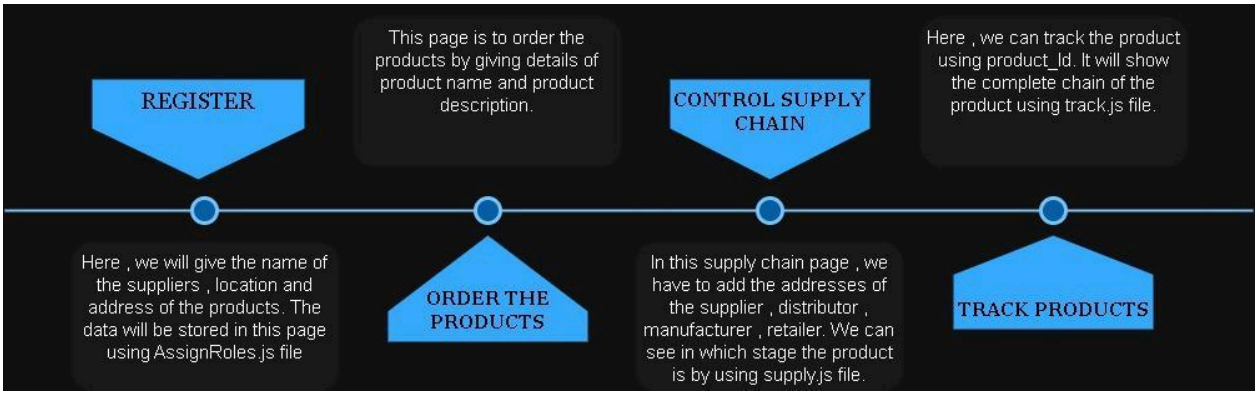


Fig. 6. Data Flow Diagram

UML DIAGRAMS:

UML stands for Unified Modelling Language. UML is a standardized general-purpose modeling language in the field of object-oriented software engineering. The standard is managed, and was created by, the Object Management Group.

The goal is for UML to become a common language for creating models of object-oriented computer software. In its current form UML comprises two major components: a Meta-model and a notation. In

the future, some form of method or process may also be added to; or associated with, UML.

The Unified Modelling Language is a standard language for specifying, Visualization, Constructing and documenting the artifacts of software systems, as well as for business modeling and other non-software systems.

The UML represents a collection of best engineering practices that have proven successful in the modeling of large and complex systems.The UML is a very important part of developing objects-oriented software and the software development process. The UML uses mostly graphical notations to express the design of software projects.

GOALS:

The primary goals in the design of the UML are as follows:

- Provide users a ready-to-use, expressive visual modeling Language so that they can develop and exchange meaningful models.
- Provide extendibility and specialization mechanisms to extend the core concepts.
- Be independent of particular programming languages and development processes.
- Provide a formal basis for understanding the modeling language.
- Encourage the growth of the OO tools market.
- Support higher level development concepts such as collaborations, frameworks, patterns and components.
- Integrate best practices

USE CASE DIAGRAM:

- A use case diagram in the Unified Modeling Language (UML) is a type of behavioral diagram defined
  by and created from a Use-case analysis.
- The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted.

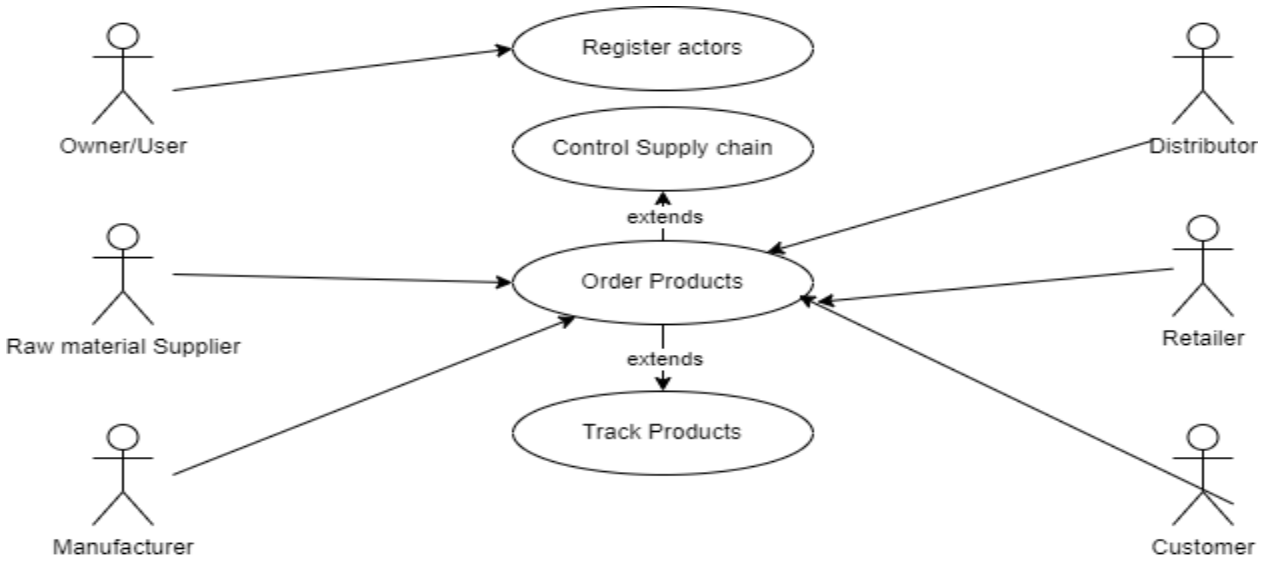


Fig. 7. Use case Diagram

CLASS DIAGRAM

- In software engineering, a class diagram in the Unified Modeling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes. It explains which class contains information.

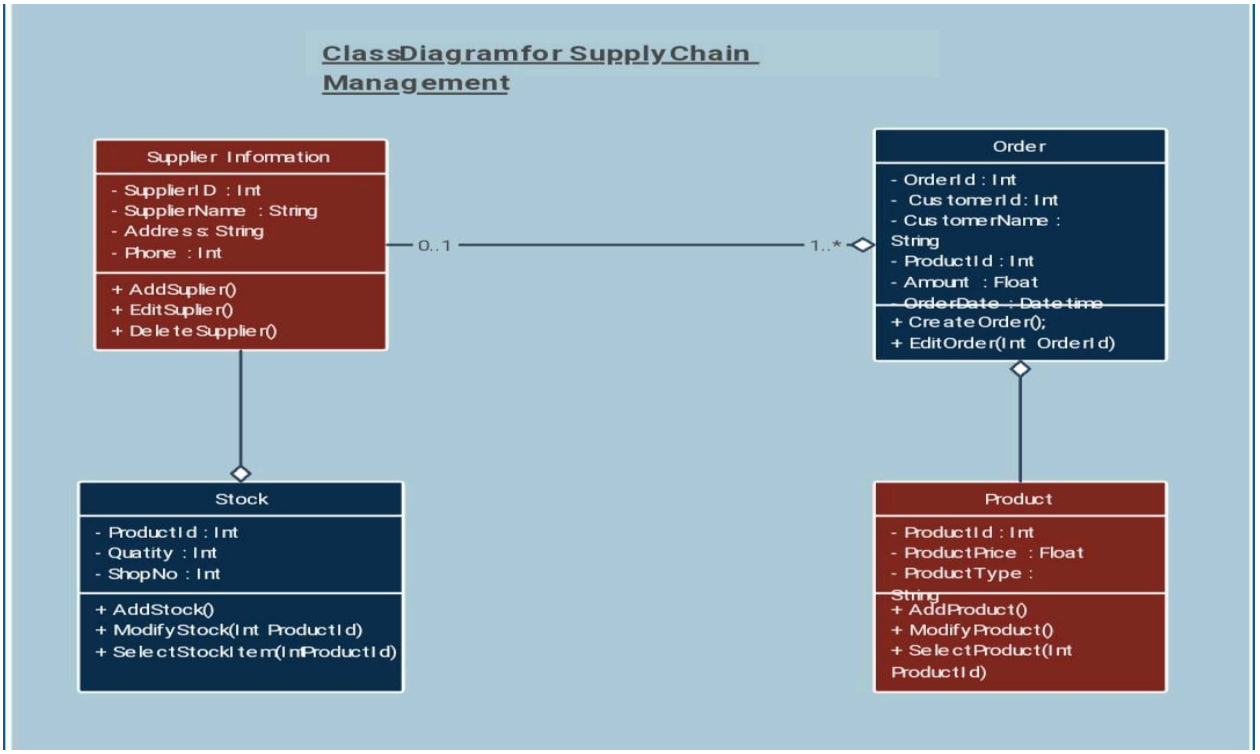


Fig. 8. Class Diagram

SEQUENCE DIAGRAM

- A sequence diagram in Unified Modeling Language (UML) is a kind of interaction diagram that shows how processes operate with one another and in what order.
- It is a construct of a Message Sequence Chart. Sequence diagrams are sometimes called event diagrams, event scenarios, and timing diagrams

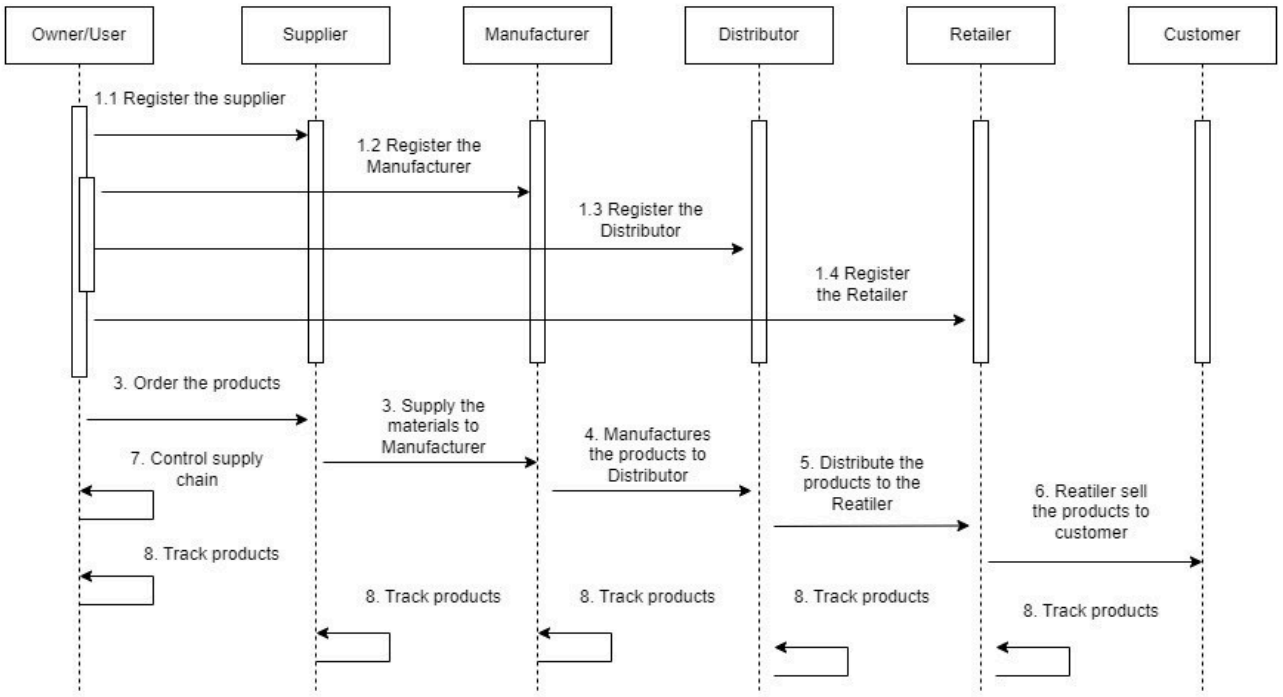


Fig. 9. Sequence Diagram

ACTIVITY DIAGRAM:

- Activity diagrams are graphical representations of workflows of stepwise activities and actions with support for choice, iteration and concurrency.
- In the Unified Modelling Language, activity diagrams can be used to describe the business and operational step-by-step workflows of components in a system. An activity diagram shows the overall flow of control.

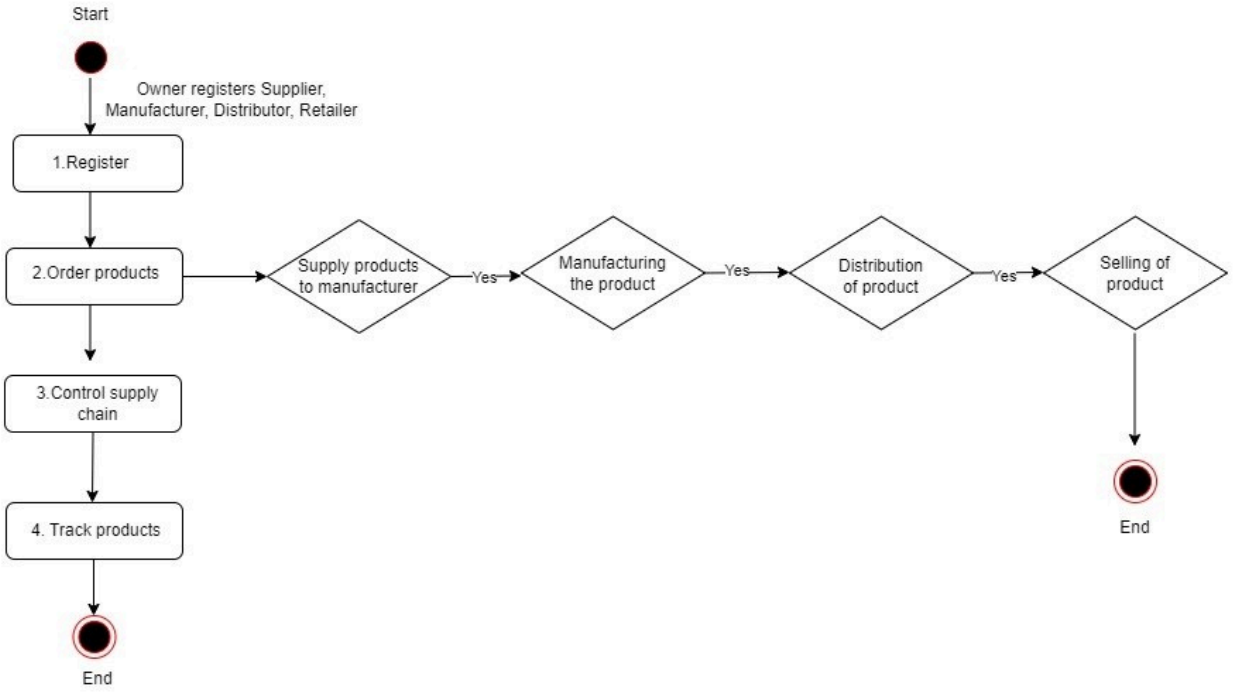


Fig. 10. Activity Diagram

5. System Implementation

2.1 Introduction

A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer and suppliers, but also transporters, warehouses, retailers, and even customers themselves. Within each organization, such as a manufacturer, the supply chain includes all functions involved in receiving and filling a customer request. These functions include, but are not limited to, new product development, marketing, operations, distribution, finance, and customer service. Through the implementation of blockchain, our project seeks to address critical pain points such as counterfeit prevention, real-time tracking, and streamlined transactions. By immutably recording every transaction and transfer of ownership on the blockchain, participants can achieve unprecedented levels of transparency and trust, thereby reducing fraud, errors, and delays.

Moreover, blockchain enables smart contracts and programmable agreements that automatically execute and enforce terms when predefined conditions are met. This feature empowers supply chain stakeholders to automate processes such as payments, compliance verification, and contract management, leading to significant cost savings and operational efficiencies. There are other additional methods for achieving supply chain management. Transactions made via techniques other than blockchain are not safe, nor are the systems that use them secure.

Thus, we can conclude that supply chain management using blockchain technology may be the optimal procedure for agreements and transactions that provide the necessary advantages for the client. People are becoming interested in projects that use new technology these days. The blockchain method for supply chain management also requires the use of numerous other technologies, such as Ganache, Metamask, Visual Studio, etc.

Ganache plays a pivotal role in the development and testing phases of our blockchain-based supply chain management project. Its multifaceted capabilities contribute significantly to enhancing the security, efficiency, and robustness of our system. Ganache serves as a comprehensive development environment tailored specifically for blockchain projects. By simulating various network scenarios and testing different use cases, developers can validate the functionality and reliability of smart contracts and decentralized applications (DApps) within a controlled environment. This iterative testing process ensures that the project meets its functional requirements and performs optimally under different conditions before deployment.

Overall, Ganache empowers our team to build, test, and deploy a robust and secure supply chain management solution powered by blockchain technology. Its versatile features and seamless integration with other development tools make it an indispensable asset in our quest to revolutionize supply chain management practices. This tool is also used for debugging to check the created test cases, one of the key components of this tool is to implement advanced encryption algorithms to ensure the confidentiality and integrity of stored data. Our project contains a separate truffle config file, which is mainly used for the ganache. Based on this file, the ganache will provide the addresses and keys for the people who are involved in developing the product or goods. So, this is the main tool for the application.

MetaMask is an extension of the blockchain wallet that manages transactions and contracts. Supply chain managers depend on MetaMask because it makes it possible for consumers to interact with blockchain applications, especially those created on the Ethereum network. We must include the metamask addon for Chrome and other search engines. In the metamask, we must construct an Ethereum project.

To link the project, the addresses and private keys generated in the ganache are added to the metamask. Transactions between the various sources will take place based on the private keys that have been added. After going through all of these phases, the items or products will finally reach the buyer. We have access to more tools that function similarly to these. Since these contracts and transactions may only be accessed by those who are utilizing the project, they will be safe and secure. They can't be changed or altered. For verification, every transaction is kept in a database or the cloud.

Popular Etherum wallet Metamask functions as a browser plugin and offers users a safe and practical interface to manage their Etherum funds and engage with decentralized apps. MetaMask makes it simple to incorporate Ethereum-based smart contracts into supply chain processes. Intelligent contracts have the potential to automate several supply chain activities, including order fulfillment, record-keeping, and payment settlement. MetaMask acts as a bridge, enabling users to interact with these smart contracts through a user-friendly interface. This guarantees the transparency and immutability of the recorded data on the Ethereum blockchain in addition to improving supply chain activities' efficiency.

Solidity is an object-oriented programming language that may be used to create EVM-compatible programs like smart contracts. It is a brand-new programming language that combines web

development, assembly language, and networking conventions. One of the most well-known blockchain platforms is Ethereum, and Solidity is a high-level programming language designed specifically for use in using these networks to create smart contracts. Supply chain management depends on solidity because it allows smart contracts to automate and execute business logic. As self-executing agreements that enact terms directly into code, smart contracts promote transparency, immutability, and confidence among supply chain actors.

Solidity makes it possible to integrate supply chain elements like transparency and traceability. Every event and transaction in the supply chain may be transparently and irrevocably recorded using the blockchain, making it accessible to all stakeholders with the appropriate authorization. This openness helps track the origin, movement, and status of products by increasing accountability and reducing the possibility of fraud or counterfeiting. All things considered, Solidity is an effective tool for raising the effectiveness and accountability of supply chain management on blockchain platforms because of its capacity to build reliable, decentralized, and automated smart contracts. Industries, factories, railroads, agriculture, and other sectors can all use this blockchain-based supply chain management system.

2.2 Project Modules

• Owner Module:

The Owner Module serves as the central control hub within our blockchain-based supply chain management system, empowering the owner with comprehensive oversight and management capabilities over the entire supply chain ecosystem.

The owner has the authority to register various stakeholders involved in the supply chain, including retailers, manufacturers, raw material suppliers, distributors, and any other relevant parties. Through this registration process, the owner establishes a trusted network of participants within the blockchain system.

The owner possesses the privilege to monitor and modify the details of products stored within the blockchain. This includes essential information such as product specifications, production dates, batch numbers, quality certifications, and any other relevant attributes. By maintaining accurate and up-to-date product details, the owner ensures transparency and traceability throughout the supply chain.

As the primary decision-maker within the system, the owner has the exclusive authority to place orders for products or raw materials. Once an order is placed, it triggers a series of events within the supply chain, prompting manufacturers, suppliers, and distributors to initiate the necessary processes to fulfill the order requirements. The owner is equipped with robust tracking capabilities that enable real-time monitoring of products as they progress through various stages of the supply chain. Leveraging the immutable nature of blockchain technology, the owner can trace the journey of each product from its origin to its final destination, ensuring visibility and accountability at every step.

• Raw Materials Supplier Module:

The Raw Material Supplier Module is designed to streamline the interaction between raw material suppliers and the broader supply chain network, offering a range of functionalities and features to enhance efficiency, transparency, and collaboration.

The module facilitates a seamless registration process for raw material suppliers, allowing them to be

added by the owner or administrator of the supply chain system. Through a user-friendly interface, suppliers can submit necessary information and credentials, enabling quick onboarding into the system. Upon successful registration, raw material suppliers gain access to the platform's order management system. Here, they can view and process orders placed by the owner or other stakeholders within the supply chain network. Using unique identifiers associated with each order, suppliers can accurately identify the required materials, quantities, and delivery specifications.

Through immutable and transparent transaction records, suppliers can track the status of each order, verify delivery milestones, and address any discrepancies or delays in transit. The module fosters seamless communication and collaboration between raw material suppliers and other stakeholders within the supply chain ecosystem.

Integrated messaging systems and notification features enable suppliers to stay informed about order updates, communicate with customers or partners, and address any queries or concerns on time. Raw material suppliers can utilize the module to maintain stringent quality control measures throughout the supply chain process. By recording quality assurance data and certifications on the blockchain ledger, suppliers can ensure compliance with regulatory standards, mitigate quality-related risks, and uphold the reputation of their products and services.

• Manufacturer Module:

The Manufacturer Module constitutes a pivotal element within our supply chain management framework, offering manufacturers a comprehensive suite of tools and functionalities to optimize production processes and enhance collaboration within the supply chain network.

Manufacturers can be seamlessly onboarded into the system by the owner or administrator. Through a streamlined registration process, manufacturers submit relevant information and credentials, gaining access to the platform's features and functionalities. Using unique identifiers associated with each supplier or material, manufacturers can efficiently source the required materials and quantities, ensuring timely availability for production processes. The module facilitates efficient production management by providing manufacturers with tools to schedule, monitor, and optimize manufacturing processes. Manufacturers can track the progress of production orders, allocate resources effectively, and manage production workflows to meet demand and delivery deadlines.

Through blockchain technology, manufacturers gain real-time visibility into the movement and status of products throughout the production lifecycle. By recording production milestones, inventory

movements, and product transfers on the blockchain ledger, manufacturers can track the provenance of each product, verify authenticity, and address any issues or discrepancies in transit. The module fosters seamless communication and collaboration between manufacturers and other stakeholders within the supply chain ecosystem. Integrated messaging systems and collaboration tools enable manufacturers to communicate with suppliers, distributors, and customers, facilitating coordination, resolving issues, and addressing inquiries in a timely manner.

• Distributor Module:

The Distributor Module is a crucial component within our supply chain management system, facilitating efficient distribution processes and fostering seamless collaboration between distributors and other stakeholders.

Distributors are onboarded into the system by the owner or administrator through a streamlined registration process. Once added, distributors gain access to the platform's features and functionalities, enabling them to participate in the distribution network. Using unique identifiers associated with each product or order, distributors procure products from registered manufacturers within the supply chain network. Leveraging the module's capabilities, distributors can efficiently obtain the required products and quantities, ensuring timely availability for distribution.

Distributors can track incoming and outgoing product shipments, monitor stock levels, and optimize inventory storage and distribution processes to meet customer demand and minimize stock outs or overstock situations. Distributors play a key role in fulfilling customer orders by supplying products to retailers within the supply chain network. Using order details and product identifiers, distributors ensure accurate and timely delivery of products to retailers, facilitating seamless transactions and customer satisfaction. Through blockchain technology, distributors gain visibility into the movement and status of products throughout the distribution process. By recording product transfers, delivery milestones, and inventory movements on the blockchain ledger, distributors can track the provenance of each product, verify authenticity, and address any issues or discrepancies in transit.

The module fosters communication and collaboration between distributors and other stakeholders within the supply chain ecosystem. Integrated messaging systems and collaboration tools enable distributors to communicate with manufacturers, retailers, and customers, facilitating coordination, resolving issues, and addressing inquiries in a timely manner.

• Retailer Module :

The Retailer Module is an essential component within our supply chain management system, empowering retailers with the tools and capabilities needed to efficiently manage sales operations and deliver exceptional customer experiences.

Retailers are onboarded into the system by the owner or administrator through a seamless registration process. Once added, retailers gain access to the platform's features and functionalities, enabling them to participate in the retail network. Using unique identifiers associated with each product or order, retailers procure products from registered distributors within the supply chain network. Leveraging the module's capabilities, retailers can efficiently obtain the required products and quantities, ensuring adequate stock levels to meet customer demand. The module provides tools for retailers to manage their inventory effectively. Retailers can track incoming product shipments, monitor stock levels, and optimize inventory storage and replenishment processes to ensure product availability and minimize stock outs or overstock situations.

Retailers utilize the module to facilitate point-of-sale operations and conduct transactions with customers. The module offers (Customer Relationship Management) CRM features that enable retailers to manage customer relationships and enhance customer satisfaction. Retailers can capture customer information, track purchase histories, and personalize marketing efforts to engage customers effectively and drive repeat business. Through blockchain technology, retailers gain visibility into the origin and authenticity of products within their inventory. By accessing product information recorded on the blockchain ledger, retailers can verify product provenance, ensure product quality, and address any concerns or inquiries from customers.

2.3 Screens

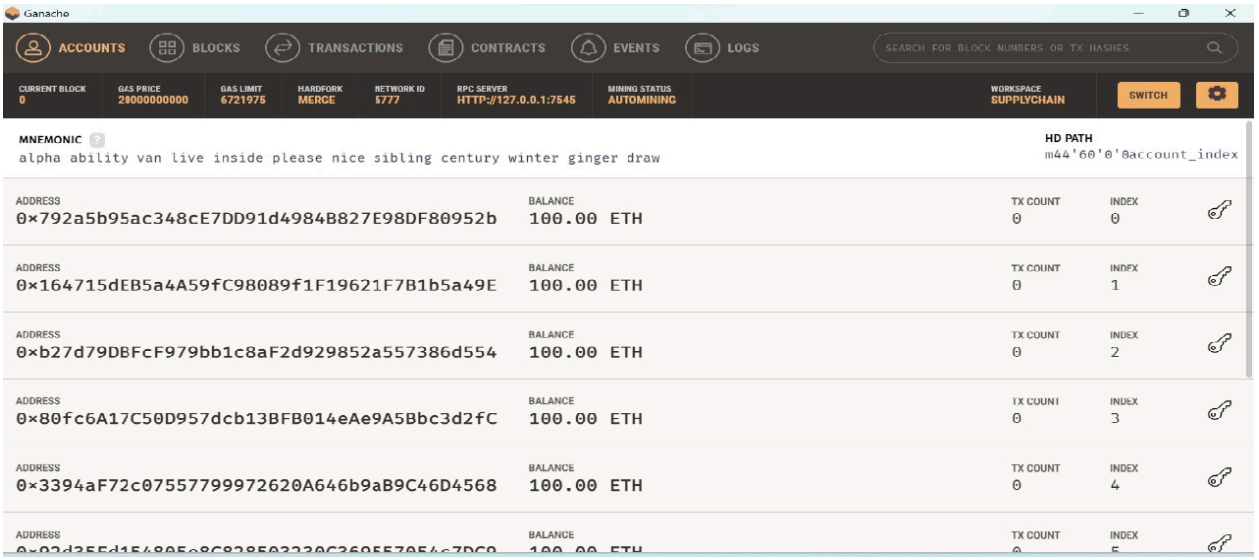


Fig 11: This is the Ganache interface which is the local blockchain where we have different ethereum addresses for actors included in the project.

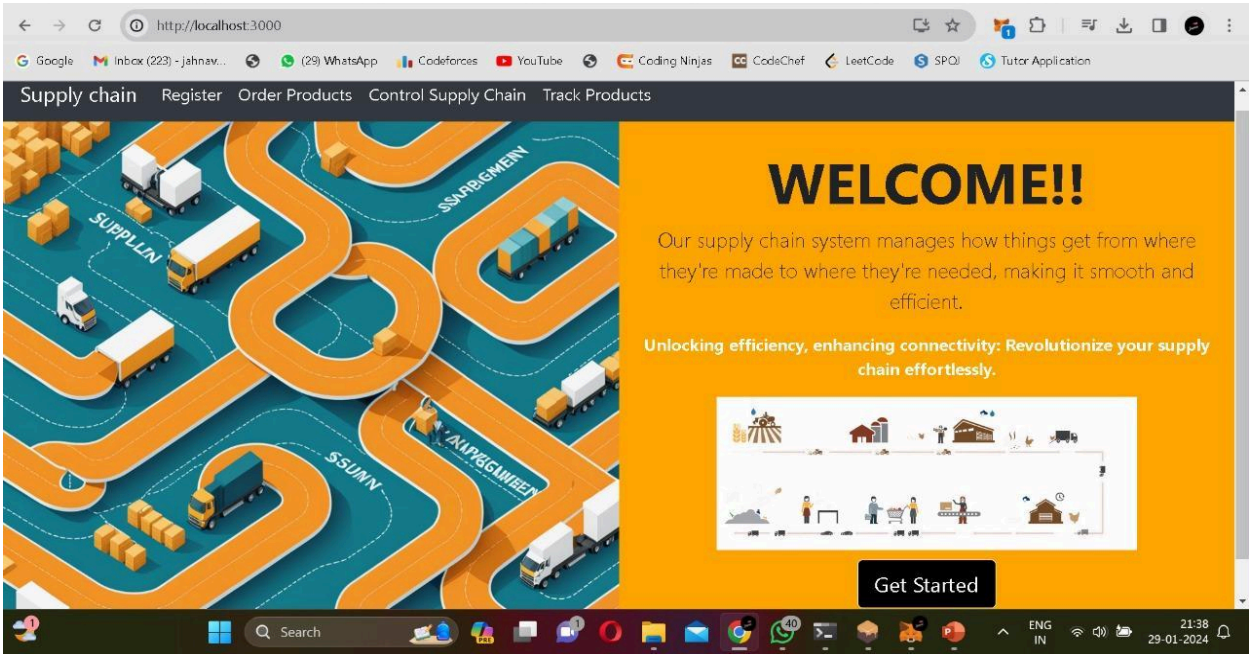


Fig 12: This is the Home page of our project which consists of navigation bar with Register, Order Products, Control Supply Chain and Track Products Options.

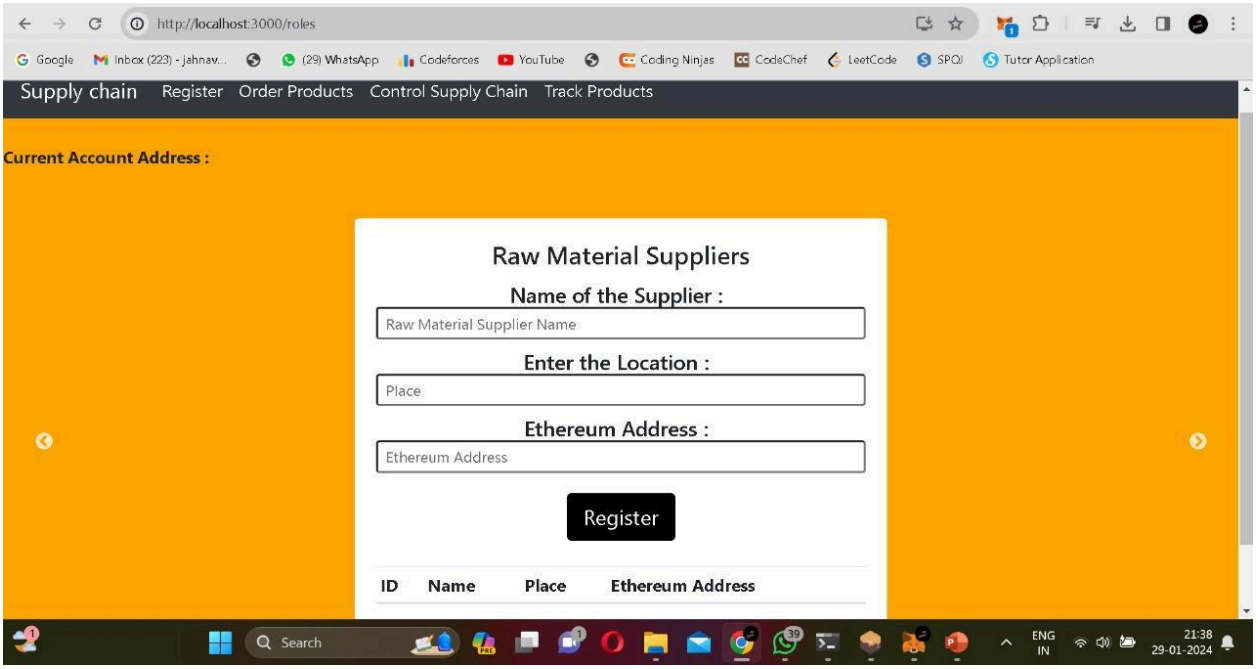


Fig 13: This is the Registration page of the project where the actors need to be registered.

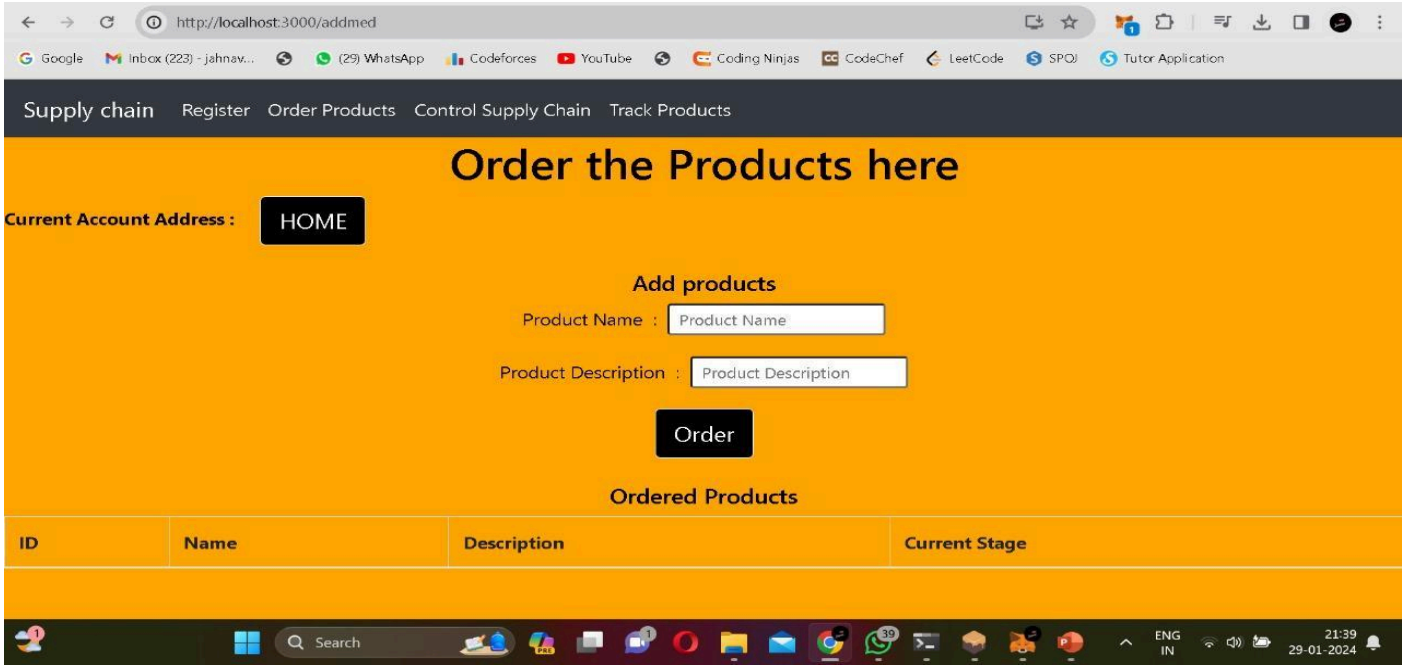


Fig 14: This is the Order Products Page where the products are ordered by using Product Name and Product Description.

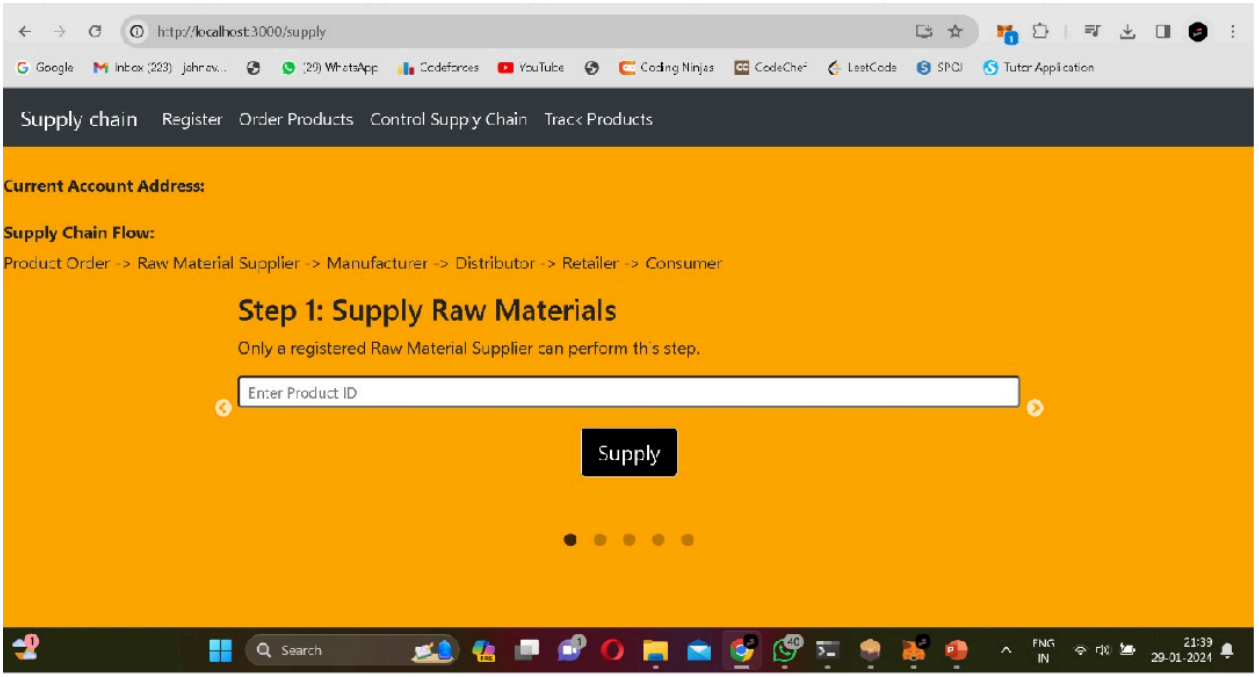


Fig15: This is the Control Supply chain Page where the product transferring is happens.

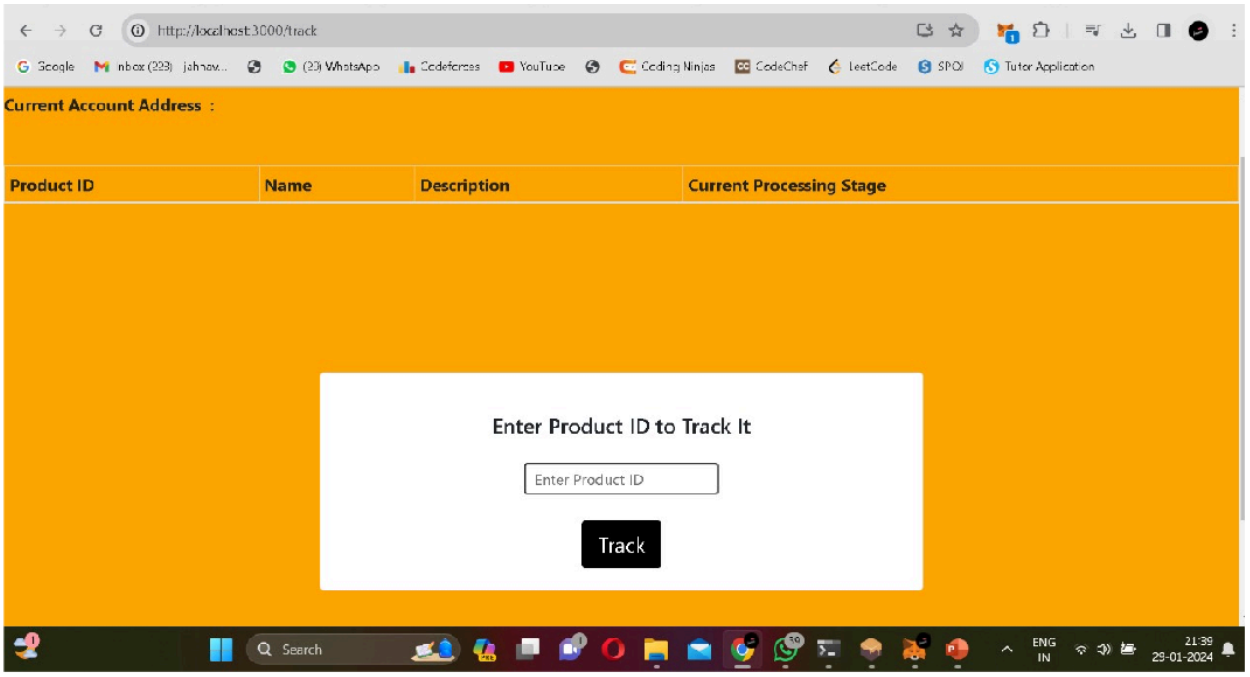


Fig 16: This is the tracking page of the project where the ordered product is tracked by using its ID.

6. SYSTEM STUDY AND TESTING

6.1 FeasibilityStudy

The feasibility of the project is analysed in this phase and business proposal is put forth with a very general plan for the project and some cost estimates. During system analysis the feasibility study of the proposed system is to be carried out. This is to ensure that the proposed system is not a burden to the company. For feasibility analysis, some understanding of the major requirements for the system is essential.

Three key considerations involved in the feasibility analysis are

- Economical feasibility
- Technical feasibility
- Social feasibility

Economical Feasibility

This study is carried out to check the economic impact that the system will have on the organization. The amount of fund that the company can pour into the research and development of the system is limited. The expenditures must be justified. Thus the developed system as well within the budget and this was achieved because most of the technologies used are freely available. Only the customized products had to be purchased.

Technical Feasibility

This study is carried out to check the technical feasibility, that is, the technical requirements of the system. Any system developed must not have a high demand on the available technical resources. This will lead to high demands on the available technical resources. This will lead to high demands being placed on the client. The developed system must have a modest requirement, as only minimal or null changes are required for implementing this system.

Social Feasibility

The aspect of study is to check the level of acceptance of the system by the user. This includes the process of training the user to use the system efficiently. The user must not feel threatened by the system, instead must accept it as a necessity. The level of acceptance by the users solely depends on the methods that are employed to educate the user about the system and to make him familiar with it. His level of confidence must be raised so that he is also able to make some constructive

criticism, which is welcomed, as he is the final user of the system.

System Testing

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, sub-assemblies, assemblies and/or a finished product It is the process of exercising software with the intent of ensuring that the

Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of test. Each test type addresses a specific testing requirement.

Types of Tests

Black box tests, as most other kinds of tests, must be written from a definitive source document, such as specification or requirements document, such as specification or requirements document. It is a testing in which the software under test is treated, as a black box .you cannot “see” into it. The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, sub-assemblies, assemblies and/or a finished product. It is the process of exercising software with the intent of ensuring that the Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of test. Each test type addresses a specific testing requirement.

System testing ensures that the entire integrated software system meets requirements. It tests a configuration to ensure known and predictable results. An example of system testing is the configuration oriented system integration test. System testing is based on process descriptions and flows, emphasizing pre-driven process links and integration points.

Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application .it is done after the completion of an individual unit before integration. This is a structural testing, that relies on knowledge of its construction and is invasive. Unit tests perform basic tests at component level and test a specific business process, application, and/or system

configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

Integration tests are designed to test integrated software components to determine if they actually run as one program. Testing is event driven and is more concerned with the basic outcome of screens or fields. Integration tests demonstrate that although the components were individually satisfaction, as shown by successfully unit testing, the combination of components is correct and consistent. Integration testing is specifically aimed at exposing the problems that arise from the combination of components.

Functional tests provide systematic demonstrations that functions tested are available as specified by the business and technical requirements, system documentation, and user manuals.

Functional testing is centered on the following items:

Valid Input : identified classes of valid input must be accepted.

Invalid Input : identified classes of invalid input must be rejected.

Functions : identified functions must be exercised.

Output : identified classes of application outputs must be exercised.

Systems/Procedures: interfacing systems or procedures must be invoked.

Organization and preparation of functional tests is focused on requirements, key functions, or special test cases. In addition, systematic coverage pertaining to identify Business process flows; data fields, predefined processes, and successive processes must be considered for testing. Before functional testing is complete, additional tests are identified and the effective value of current tests is determined.

6.2.Testing Methods:

White Box Testing:

White Box Testing is a testing in which the software tester has knowledge of the inner workings, structure and language of the software, or at least its purpose. It is purpose. It is used to test areas that cannot be reached from a black box level.

Black Box Testing:

Black Box Testing is testing the software without any knowledge of the inner workings, structure or language of the module being tested. Black box tests, as most other kinds of tests, must be written from a definitive source document, such as specification or requirements document, such as specification or requirements document. It is a testing in which the software under test is treated, as a black box .you cannot “see” into it. The test provides inputs and responds to outputs without considering how the software works.

Unit Testing:

Unit testing is usually conducted as part of a combined code and unit test phase of the software lifecycle, although it is not uncommon for coding and unit testing to be conducted as two distinct phases.
Test strategy and approach
Field testing will be performed manually and functional tests will be written in detail.
Test objectives
All field entries must work properly.
Pages must be activated from the identified link.
The entry screen, messages and responses must not be delayed.
Features to be tested
Verify that the entries are of the correct format
No duplicate entries should be allowed
All links should take the user to the correct page.

Integration Testing:

Software integration testing is the incremental integration testing of two or more integrated software components on a single platform to produce failures caused by interface defects.
The task of the integration test is to check that components or software applications, e.g. components in a software system or – one step up – software applications at the company level – interact without error.
Test Results: All the test cases mentioned above passed successfully. No defects encountered.

Acceptance Testing:

User Acceptance Testing is a critical phase of any project and requires significant participation by the end user. It also ensures that the system meets the functional requirements.

Test Results: All the test cases mentioned above passed successfully. No defects encountered.

7. CONCLUSION

The incorporation of blockchain technology into supply chain management (SCM) has resulted in a revolutionary change, enabled by platforms such as Ganache and MetaMask. This convergence improves transparency, traceability, and overall efficiency by addressing important industry concerns.

Blockchain, as a decentralized and immutable ledger, ensures a single version of truth across the supply chain. This is especially important in supply chain management (SCM), as there are numerous parties involved, each with their own data and set of procedures. Every link in the supply chain can obtain a transparent and safe transaction record by utilizing blockchain technology. This fosters trust and minimizes the risk of discrepancies or fraudulent activities.

The use of Ganache, a personal blockchain for Ethereum development, provides a practical and controlled environment for testing and simulating blockchain applications. It allows SCM professionals and developers to experiment with various scenarios, ensuring the robustness and reliability of the implemented solutions before they are deployed in a production environment.

A wider spectrum of enterprises can now access blockchain development with Ganache's cost-effective and scalable approach. Because of Ganache's versatility and ease of use, developers can design customized solutions to solve certain supply chain problems. Its characteristics support the creation of safe, open, and effective systems, building stakeholder confidence and setting the stage for an ecosystem of the supply chain that is more responsive and resilient.

MetaMask, a cryptocurrency wallet and gateway to blockchain applications adds another layer of usability to the SCM ecosystem. With MetaMask, users can seamlessly interact with blockchain-based supply chain applications, making the technology more accessible and user-friendly. For broad adoption by all parties involved in the supply chain—from producers and distributors to retailers and customers—this inclusion is crucial.

By lowering the possibility of fraud, unauthorized access, and data manipulation, this improves the overall security of the supply chain data and transactions. MetaMask simplifies the blockchain's complexity, making it easier for users to interact with it. Non-technical users may interact with

smart contracts, track product provenance, and confirm authenticity throughout the supply chain more easily because of its user-friendly interface and straightforward architecture.

The entire supply chain ecosystem is made more transparent, secure, and efficient through the use of Solidity, a programming language created for Ethereum blockchain smart contracts. By utilizing Solidity smart contracts, stakeholders within the supply chain can automate and streamline various processes, including tracking and verifying the authenticity of products, recording transactions, and enforcing contractual agreements.

Supply chain players are more likely to trust one another because of the immutability and decentralized nature of blockchain, which guarantee transparent and tamper-resistant data. 6A groundbreaking approach that solves a number of the problems with conventional supply chain systems is Solidity for Supply Chain Management, which leverages blockchain.

An ecosystem for the global supply chain that is more dependable and trustworthy is made possible by the integration of smart contracts written in Solidity, which increases efficiency, transparency, and security.

In summary, a new era of effectiveness, openness, and confidence in supply chain management is ushered in by the combination of blockchain with Ganache, MetaMask, and solidity. By providing a safe and efficient method of handling the intricate network of exchanges and transactions in the supply chain, this technological synergy resolves long-standing problems in the sector. The potential advantages of this technology are enormous for both consumers and businesses, and it will open the door for a more responsive and robust global supply chain ecosystem as it develops and gains traction.

SOFTWARE INSTALLATION FOR SUPPLY CHAIN BLOCK CHAIN :

Installing Metamask:

1. Open Chrome Web Store : Open your Google Chrome or Brave browser and go to the Chrome Web Store.
2. Search for MetaMask : In the search bar of the Chrome Web Store, type "MetaMask" and press Enter.

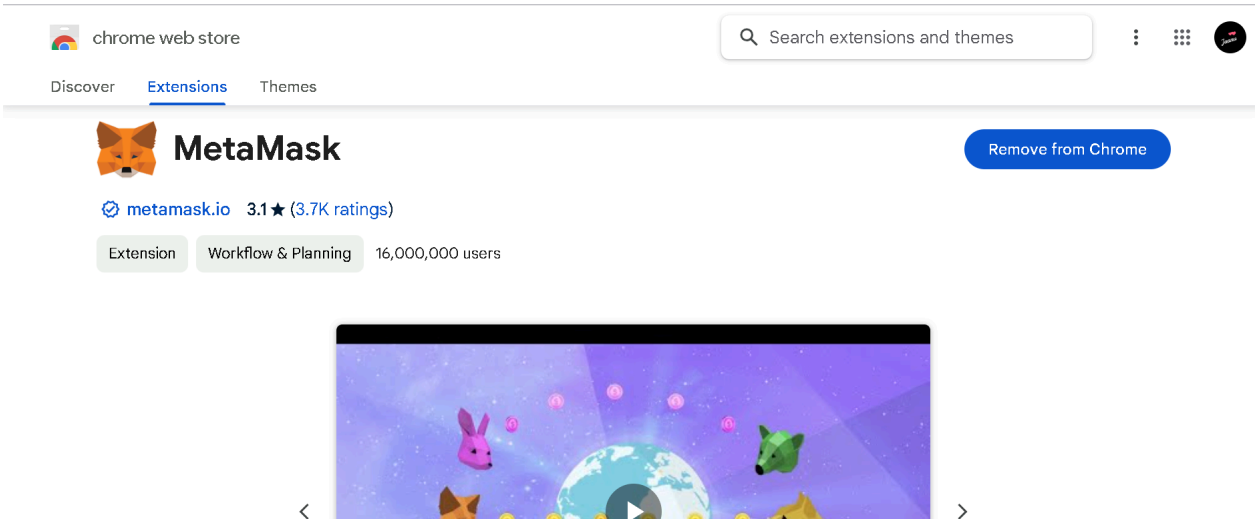


Fig 17: Installation of Metamask

3. Add MetaMask Extension: Look for the MetaMask extension in the search results and click on it.
4. Add to Chrome: Click on the "Add to Chrome" button to install the MetaMask extension.
5. Confirm Installation: A confirmation dialog will appear. Click "Add Extension" to confirm and install MetaMask.
6. Open MetaMask: After installation, you'll see the MetaMask icon added to your browser's toolbar. Click on it to open MetaMask.

Installing Ganache:

1. To install Ganache on Windows, you can follow these steps:
2. Visit the official Ganache website: [Ganache](https://www.trufflesuite.com/ganache), and navigate to the download section

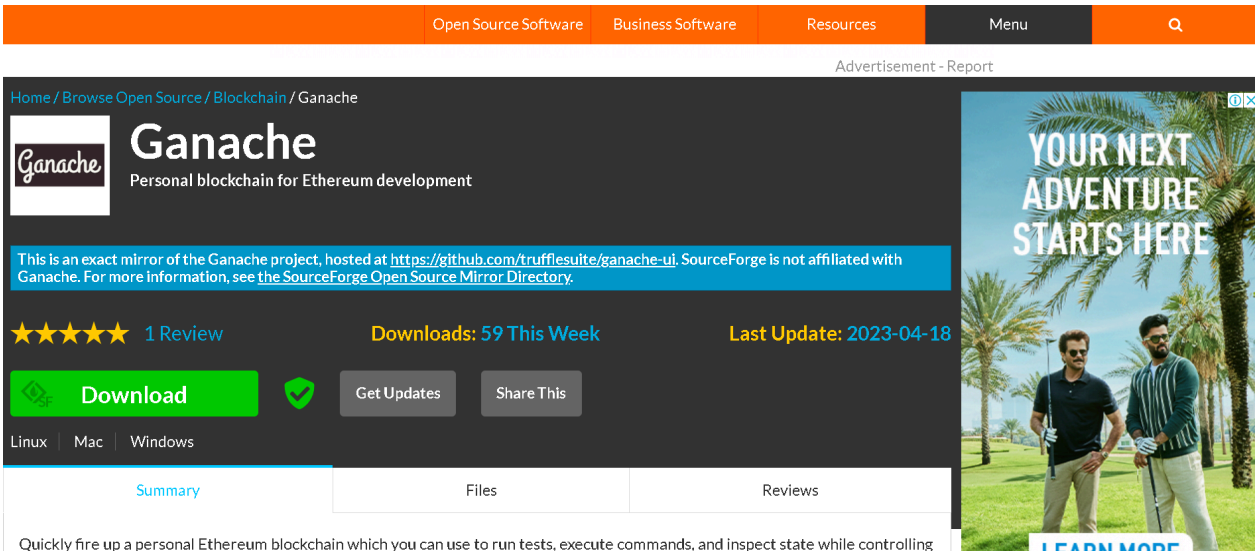


Fig 18: Installation of Ganache

3. Click on the download button for the Windows version of Ganache. It typically comes as an executable installer file (.exe).
4. Once the download is complete, locate the downloaded .exe file (usually in your Downloads folder) and double-click on it to run the installer.
5. Follow the instructions provided by the Ganache installation wizard. This typically involves selecting the installation directory, agreeing to the terms of service, and clicking through the installation process.
6. After the installation is complete, you may be prompted to launch Ganache immediately. If not, you can find Ganache in your Start menu or desktop shortcut and launch it from there.

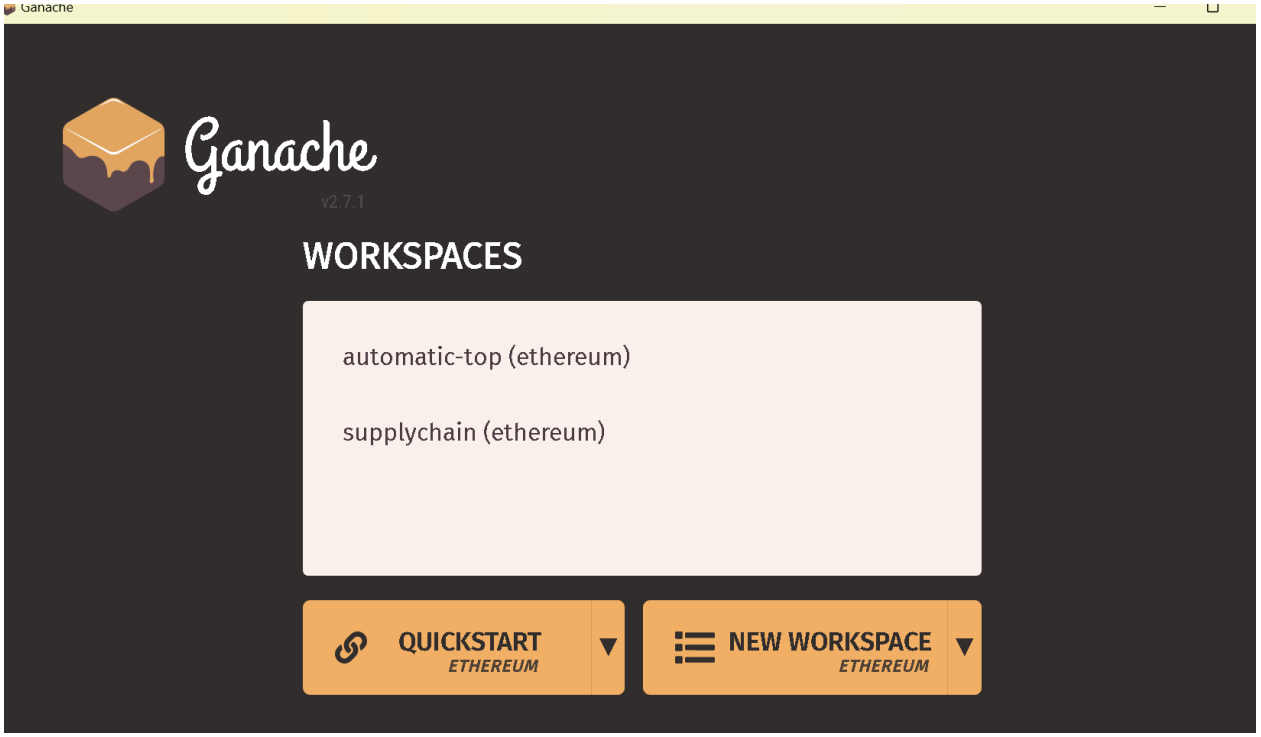


Fig 19: Ganache creation of workspace

7. Double-click on the Ganache shortcut to run the application. This will start Ganache, and you'll see a window with details about your local Ethereum blockchain, including accounts, private keys, and transaction history.
8. You may want to configure Ganache settings according to your requirements. This includes setting the number of accounts, the initial balance of each account, network ID, gas limit, and other advanced settings.

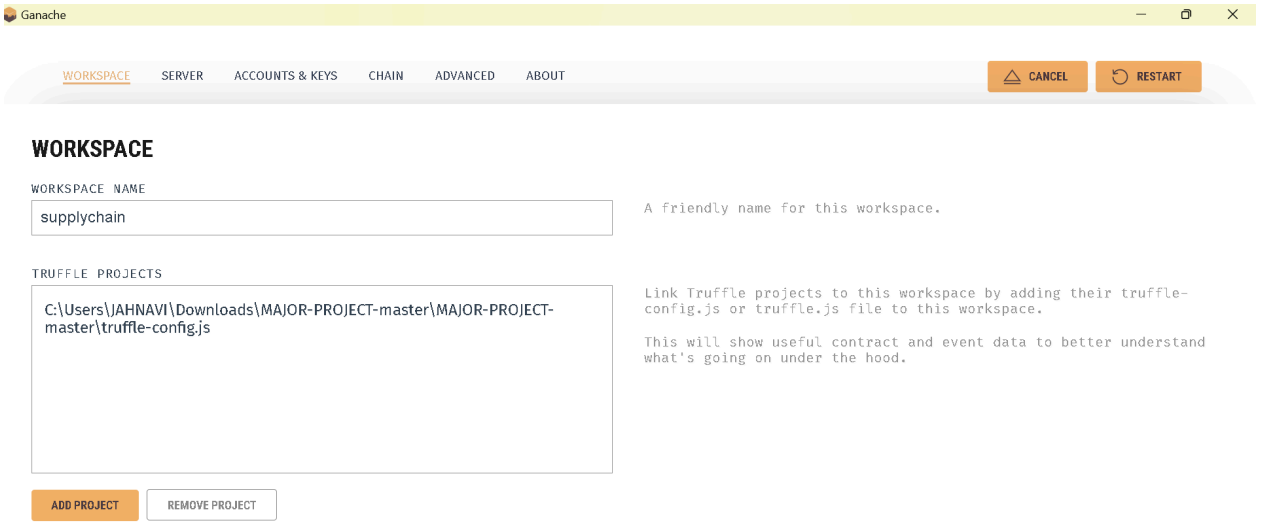
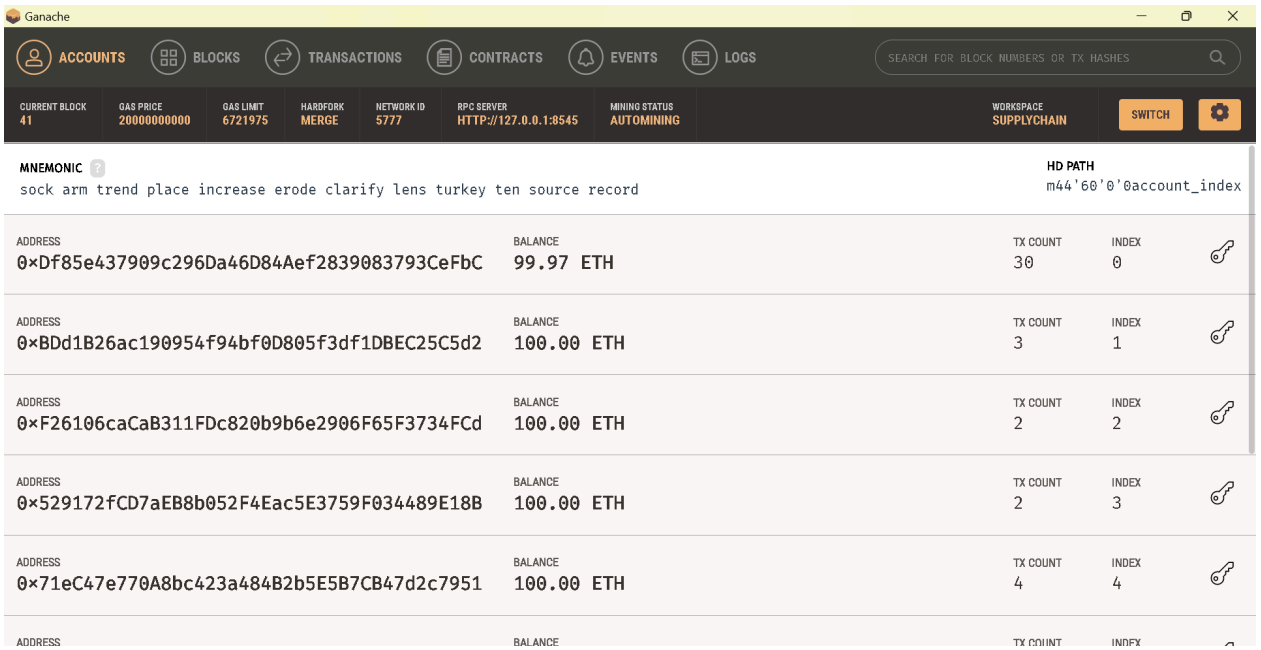


Fig 20 : Ganache workspace

9. Once Ganache is running, you can connect it to your development environment, such as Remix, Truffle, or web3.js, to deploy and interact with smart contracts and develop Ethereum-based applications.
10. With Ganache installed and running, you now have a local Ethereum blockchain environment ready for development and testing. You can deploy smart contracts, interact with them, and debug your applications locally before deploying them to the Ethereum



mainnet. Fig 21: Ganache workspace addresses

NODE MODULES USED FOR BLOCKCHAIN PROJECT:

1. npm install truffle:

This command installs Truffle globally on your system. Truffle is a development environment, testing framework, and asset pipeline for Ethereum. It allows you to write, compile, deploy, and test smart contracts on the Ethereum blockchain.

2. npx truffle migrate:

This command is used to migrate smart contracts to the Ethereum blockchain. Migrating contracts involves deploying them to a specified network (such as a local development network or a public testnet). Before running this command, ensure you have configured your Truffle project and specified the network settings in the `truffle-config.js` file.

```
C:\Users\JAHNAVI\Downloads\Blockchain-SCM-main\Blockchain-SCM-main\client>npx truffle migrate

Compiling your contracts...
===========================
> Compiling .\contracts\Migrations.sol
> Compiling .\contracts\SupplyChain.sol
> Artifacts written to C:\Users\JAHNAVI\Downloads\Blockchain-SCM-main\Blockchain-SCM-main\client\src\artifacts
> Compiled successfully using:
   - solc: 0.5.16+commit.9c3226ce.Emscripten.clang
Network up to date.
```

Fig 22 : Commands to run the project

3. npx truffle compile:

This command compiles your smart contracts. Truffle automatically compiles contracts when needed (for example, before migration or testing), but you can explicitly compile them using this command.

Fig 23 : Commands to run the project

4. npm run start:

This command is typically used to start a development server for a web application. If your project includes a front-end application (e.g., built with React, Vue.js, etc.) and you have configured a start script in your `package.json`, running `npm run start` will start the development server and allow you to view your application in a web browser.

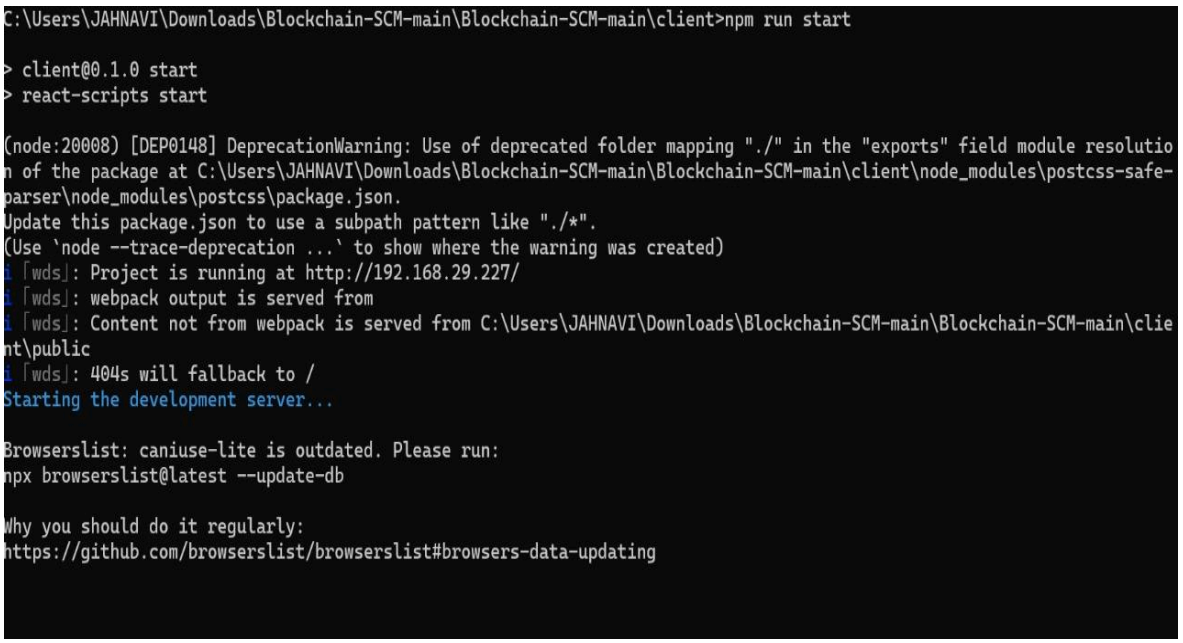


Fig 24 : Commands to run the project

Before running these commands, ensure that you have initialized a Truffle project (`truffle init`), written your smart contracts, and configured your `truffle-config.js` file with the appropriate network settings. Additionally, make sure you have installed Node.js and npm on your system.

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