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PRODUCT TRACKING AND FAKE PRODUCT IDENTIFICATION USING BLOCKCHAIN

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Abstract: **Product Tracking refers to the process through which a product or a commercial item can be traced or located with respect to its time, location, owner and other substantial information. In a supply chain system, the products in that chain should remain tamper-proof to ensure that a fake or unwanted product is not delivered to the end-users. The aim of the product tracking and fake product identifier is to ensure that the well being of all the products in the supply chain is maintained as well as to ensure that the useful information like timestamps and past location of a given product is accessible to every participant of the supply chain which includes distributors, retailers, manufacturers etc.**

Keywords – **Tracking, Ethereum, Blockchain, Smart Contracts, Supply Chain, Products**

I. INTRODUCTION

Since the past few decades, the act of tampering with products has steadily increased. Assuming a product is moving from the manufacturer to the distributor at one point in the supply chain, someone can perceive this as a chance to make a profit by replacing the original product with a fake copy so they can sell the original product elsewhere. This can result in a counterfeit product being delivered to the end-users who unknowingly use them perceiving them as the original one. According to statistical data, over the previous three years there has been a 23% increase in the number of people using counterfeit goods. Customers who are dissatisfied with the items criticize the company, which could harm the company's reputation. A big catastrophe could also ensue if critical products like pharmaceuticals are tampered or replaced with fake goods.

The current systems and strategies that are adopted by different companies to prevent the flow of counterfeit goods in the supply chain are not very transparent or reliable. Even if it is determined that the product is tampered, it is difficult to pinpoint the exact location and time where the counterfeit goods have been added in the supply chain. A big aspect that leads to the failure of these systems is the centralized architecture adopted by them. It can lead to single point failure and create distrust among the users of the system.

The system that is described in this paper is a decentralized application for tracking and authenticating products in a supply chain based on Ethereum Blockchain. [9] Stakeholders in a variety of industries, including finance, healthcare, utilities, real estate, and government, have recently become interested in blockchains. This sudden surge in attention is caused by: The ability of blockchain systems and technology to develop programmes that could run in a decentralized fashion which previously had to depend on a middleman, thereby eliminating them. As the need for a central authority is eliminated, the same functionality with an equal level of assurance can be achieved with the help of Blockchain. Because transactions can be made even when parties do not trust one another, blockchain enables trustless networks. All network interactions are made authoritative by the extensive use of cryptography. These notions are integrated into smart contracts, which are the scripts having an ability to self-execute themselves, that live on the blockchain and enable proper, distributed, highly automated workflows.

Our system takes into consideration the two major aspects of security risks that we have discussed earlier: Accountability and Decentralization. Accountability is assigning each member of the supply chain their respective duties and holding them accountable for their activities. This includes authorization as well as maintaining integrity (secured transactions). Decentralized application will ensure the immunity from single point failure.

II. LITERATURE SURVEY

This section examines and clarifies the work done on product tracking systems as well as the implementations to help countering the counterfeit product in the supply chain systems. We also look at a variety of applications that employ blockchain technology for solving similar issues.

The authors in paper [1] have spoken about using a distributed blockchain based technology for data storage as a method for implementing an anti-counterfeiting traceability system or ACTS. The traditional data storage system has the risk of being tampered with if the entities in the supply chain are corrupted and involved in fleecing or counterfeiting of goods. Producer, Retailer and Consumer were the three entities considered to be a part of the supply chain. Four different scenarios or stages were taken into account, and how entities would act in that situation was showcased. They were namely Q, H, J and C. The author also spoke about the terms such as wholesale price w^i, circulation loss ψ^i, demand function D^i, retail price p^i , and blockchain investment cost c and how they are calculated considering the consumer requirements.

In paper [2], the authors have demonstrated the creation of an asset tracking system for displaying the location or co-ordinates of locomotives and maintenance-of-way vehicles in real-time. This system or methodology was implemented using the Global Positioning System or GPS and Motorola i730 DEN headsets. A JAVA based application was also deployed which automatically starts running when the device is supplied power and constantly monitors the location of the asset. This cellular based technology was adopted as the satellite technology was not cost effective and couldn't provide near real time data feed.

In paper [3], the authors have spoken about how the rise in population of the urban areas has also led to adaptation of smart technologies to make lifestyle better but which has also led to cybercrimes in these regions. The traditional security frameworks were not effective as they were still faced with a number of threats namely Availability, Integrity, Authenticity and Accountability threats. The author split the security framework into 4 layers. They were Physical, Communication, Database and Interface layers. The Blockchain technology was proposed to be implemented in the 2nd layer of communication, this included hashing of the transaction messages before sending them over the network for allowing the message to be cross-checked before committing the transaction as blockchain is known for being immune to tampering and other cyber attacks.

The authors in paper [4] have discussed the adaptation of IOT technology in the industry of agriculture. They also spoke about the constant monitoring of these perishable items and their environment to ensure freshness but as the data storage system used traditionally is centralized it is more susceptible to being a single point of failure and being tampered. They suggested the integration of IOT with Blockchain as a storage medium where the sensor data would be directly stored on the Blockchain without any human intervention by the use of smart contracts based automation. They also suggested the creation of APIs for exposing the implementation to existing systems. The system was implemented by using two technologies viz. Ethereum and Hyperledger Sawtooth.

In paper [5], the authors have discussed various techniques to identify counterfeit products in real world scenarios. The impacts of such products on the financial sector and reputation of real-world companies were also discussed. The primary techniques that were discussed in this paper include QR codes, Radio-frequency identification (RFID) and barcodes. The authors have briefly evaluated these techniques and suggested using them based on different situations.

According to the authors of paper [6], the wine sector could benefit from a system that can be used to protect brands and enable a solution which would be useful for detecting fake products. It would be based on smart tags and technologies that work in a cloud environment. The basic idea is to utilize the responses from the code quickly, using different inks like the functional ones, a cloud platform, and enabling communication from both ends (winemaker and the end user). This is the fundamental principle behind smart tags.

In the paper [7], the authors have put forward a blockchain based tracking system for an E-commerce platform which serves as manufacturer, supplier and retailer. The authors have discussed the advantages that a blockchain-based system has over the traditional approach in designing such a system.

These advantages include minimizing the errors, fraudulent activities and delays on the platform.

In the paper [8], the authors have put forward a prototype that is based on Blockchain and takes into consideration a supply chain environment for testing the prototype. This prototype could be used in theoretical studies which can be used in the development of a self-reliant supply chain based on the blockchain technology which in turn could be used for quality management. This supply chain system could then be used as a base for development of resource management systems. The system would be capable of working in distributed environments. It can be implemented in virtual organizations which work in distributed environments. Such systems have an important place in cross-organizational and decentralized management theory.

According to the authors of paper [9], a combination of blockchain and IoT is very beneficial and can have many real life use cases. Here, a blockchain based system creates a trustable environment for all our peers with a cryptography feature which helps in creating immutable data thus less prone to data modification attacks. The processes for the blockchain applications can be automated with the help of smart contracts. The IOT based system considers the devices as our points of contact. These systems, when used together, help us to automate repetitive procedures in new and innovative ways, with cryptographic verifiability.

Authors of paper [10], proposed a Hyperledger fabric five-layer blockchain integrated with Internet of Things to provide a smart traceable platform for the drug supply chain. It introduces the pharma industry to blockchain application and its real life uses. Also, the platform's feasibility and practicability have been validated using the Hyperledger Fabric blockchain.

Authors of paper[11], suggested a Blockchain application for land registry system. Features like transparency and cryptography secured systems helped in securing property

ownership records by making them immutable and available at all times.
Authors of paper [12], discussed utilizing the blockchain technology in supply chain networks to create a trustworthy environment. Here, the use of smart contracts facilitates peer-to-peer transactions in a secured environment without any use of middlemen for the supply chain network.
According to the paper [13] which was released in the year 2005, the product tracking and management system has proven to be a workable method for both tracking hospital employees and preventing further equipment loss.
According to the paper [14] which was released in the paper 2018, the author discussed the use of blockchain for enhancing the resilience of existing supply chains. The author discusses the advantage of decentralized, immutable and traceable nature of blockchain, how it can be used to avoid fishy or malicious activities, as well as trace the malicious activity right back to its source if any is conducted due to the chain-based storage feature offered by blockchain.
According to the paper [15] which was released in the paper 2008, the author discussed the use of a wireless sensor network in asset tracking service. The author described the disadvantages of performing manual and barcode-based asset tracking in the various industries, and later counted out the benefits of using WSN based systems like ZigBee for asset tracking. The paper further went on to explain the use of the said system in hospitals, its implementation and how it can help with faster service time for patients in need of critical care.

III. DESIGN

This section discusses the different analysis diagrams like the block diagram, flowchart and sequence diagram.

A. Block diagram

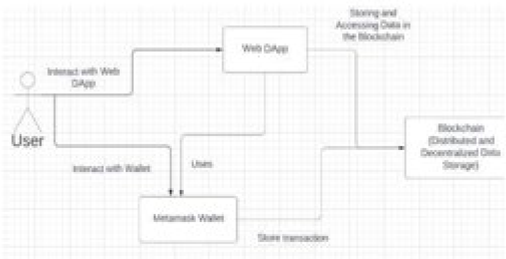

Fig.1 Block diagram

In Fig 1, Web Dapp represents the frontend i.e. UI of the website from where the input is taken. The UI will further interact with the blockchain using the web3.js libraries to do the further processing for the data in the blockchain.

The Metamask Wallet block represents the wallet of the user which is used to process the payments for the transactions that the user wishes to do. All these transactions are stored in the blockchain database. The fee for the operation is referred to as the gas fee. The Blockchian block represents the blockchain database where all the data about the products, the transferring of the products, etc. are stored.
Every time a transaction is performed i.e, an operation of moving a product in the supply chain is done, there is a certain amount of fee which is deducted from the metamask wallet of the user account associated with it. The transaction would only occur if the gas required for the operation is less than or equal to the balance available for the particular user account. The metamask wallet provides the support for adding multiple user accounts, each having their own balance and user information. This metamask wallet thus serves as a very important part in the operations of our supply chain system.

B. Flowchart represents the basic flow of DApp in transferring a product from manufacturer to end Customer.

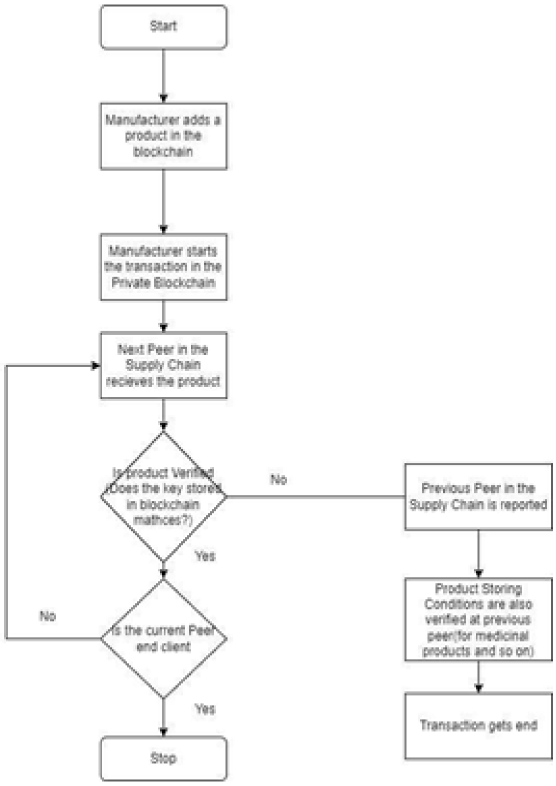

Fig 2. Flowchart depicting general flow

In Fig.2, here, first of all the manufacturer adds the product by paying the gas fee in the blockchain. Then, the transaction is started when desired by the manufacturer.
Here, then the next peer in the supply chain receives the product. Then, this peer verifies the product.
If the product is not verified then the previous peer in the supply chain is reported. Also, the current peer can also

check whether or not the conditions in which the product was stored, like temperature and all, were correct or not. This discrepancy is then resolved by using the product tracking feature where the peers can see where the product was, what was the temperature at that location.

If the product is verified, then if the current peer who received the product is the end Customer, then the transferring of the product gets stopped or else the current peer transfers the product to the next peer where again the process of verifying the product goes on.

C. Flowchart for transferring the product

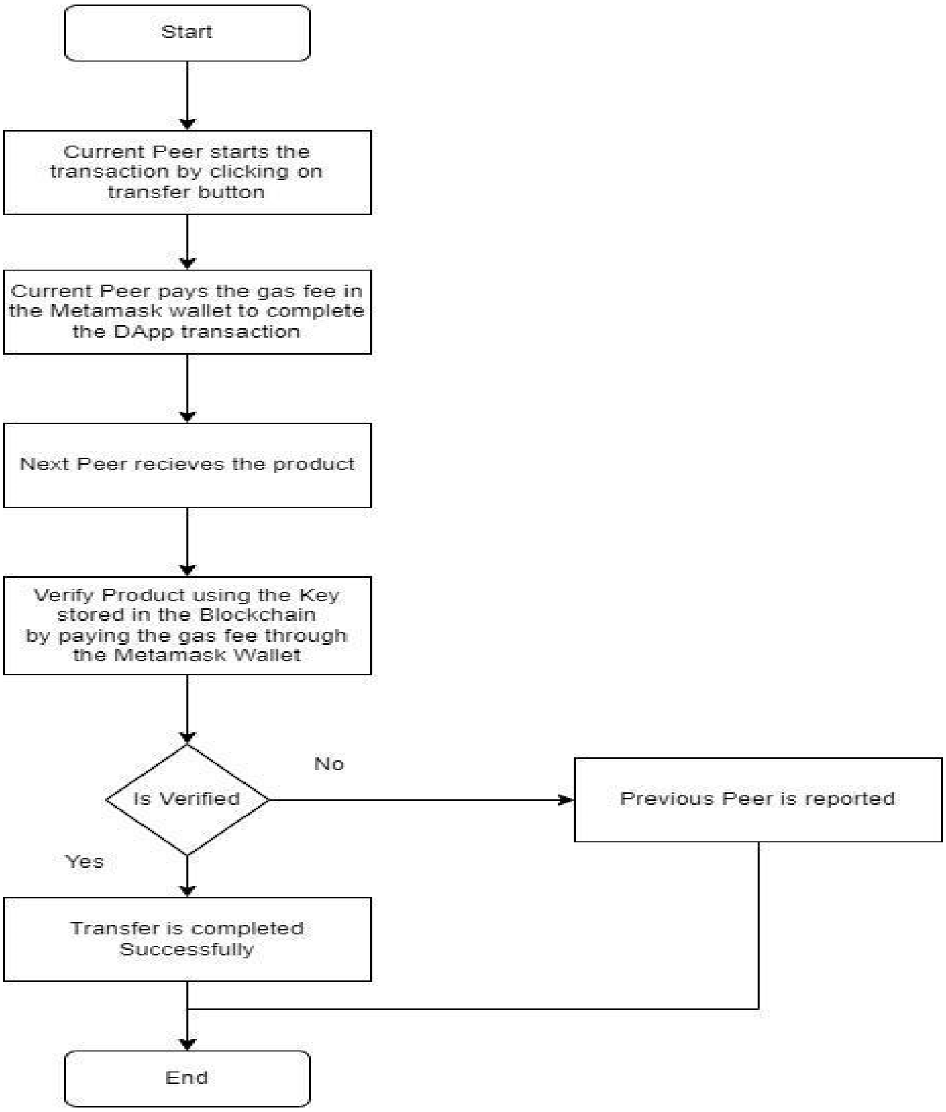

Fig 3. Flowchart for transferring of product

Here, for transferring the product, the current peer chooses the Transfer Option and fills the required details of the user to which the product is to be transferred. Then, the current peer pays the gas fee for this transaction through the metamask wallet and on the successful payment of the gas fee of the respective transaction the product is supplied to the next peer. Here, while the product is supplied any of the peers can track the product details i.e its location, the temperature of the surrounding in which product is there.

After the next peer receives the product, he/she verifies the product by matching the QR code key with the QR code key

stored in the blockchain (where the QR code was generated by 256-bit hash key).
If the key gets matched then the product gets matched or else the previous peer who started this transferring of the product gets reported about the same.

D. Flowchart for creating product

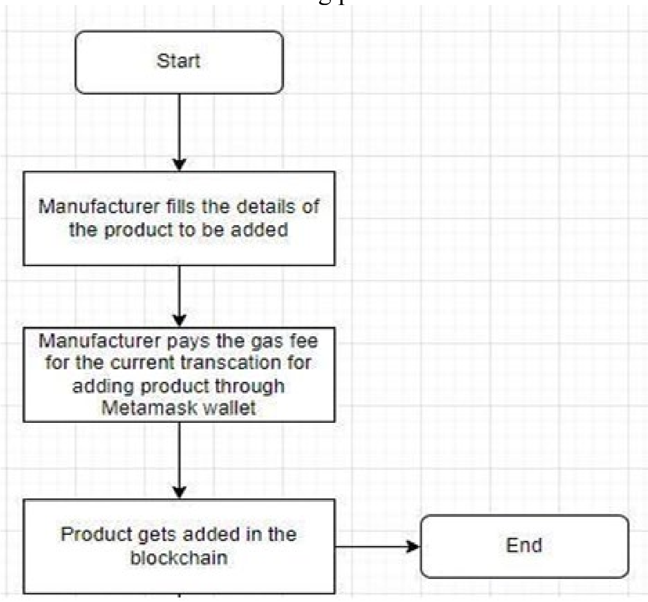

Fig 4. Flowchart for creating product processes

In Fig 4, the manufacturer first of all selects the option to Add Product, and then fills the required details of the product to be added. Then, the manufacturer pays the gas fee for processing the transaction through the metamask wallet, and on successful completion of the payment process the product gets added to the blockchain.

IV. PROPOSED METHODOLOGY

This paper proposes the use of Blockchain Technology for implementing a decentralized and reliable supply-chain management system. The proposed methodology of this paper has been divided into three sections to provide easily understandable content to the user.

A. Technology Used
Solidity Programming Language was used as the preferred language for developing smart contracts. As the proposed methodology was targeting EVM (Ethereum Virtual Machines), we found it suitable for using Solidity as it's used in the implementation of Ethereum Smart Contracts. Truffle Suite was used as the preferred framework for building, testing and deploying the smart contracts on the test network due to its clear and comprehensive documentation. Ganache Toolkit was used for setting up the private test network due to its compatibility with Truffle Suite and easy-to-use GUI. HTML, CSS and JS were used in the development of the frontend and for implementing the interacting with the private blockchain network. NodeJs framework was used for firing up a live-server instance on port 3000 on the local host. Metamask extension was used as the default wallet for users on the private network, and for the confirmation of transactions performed by the Web3 Framework.

B. Smart Contracts created and their working.
The Keccak-256 hashing technique is used to produce the unique hash key for a product and generate the QR code for it which will be useful in the verification process of the products. Also, the smart contract was created using Solidity object-oriented programming language. A single smart contract by the name of "Asset Tracker" was created. The contract made use of three user-defined structures going by the name "Identity", "Asset", and "Failure" for storing user, product and fault information on the blockchain network. Here, Identity struct stores a mapping "owned Assets" which maps the assets of that particular user. Also it has important personal details like email, address, position in supply chain(i.e whether the user is a Manufacturer, Distributor or someone else). The Asset struct basically stores details about an asset like its asset Uid, the current owners address and some flags to denote whether the asset is being declared as genuine and whether it is verified by the current supply chain member to which this asset was transferred. AssetStore and Identity Store mapping was created which will act as an array for storing the different assets and user information in the smart contract on the blockchain.
The create Identity() function first of all checks whether the user already has an account or not by the help of email and the address, and if the user doesn't have an account then the user details are stored as new object in "Identity Store" with the password value being hashed by Keccak256 hashing technique.
The log In Identity() function was used to authenticate the user by comparing the Keccak256 hash of the password in the Log-In Form with the password hash stored on the blockchain. It basically used an if condition along with keccak 256() function to do the same.
The create Asset() function in the smart contract was called every time a valid user submitted a form for asset creation on the blockchain. This function will first perform three checks before moving ahead with the creation of the product. The first check is to verify if the user is a valid user on the blockchain network, second is to check whether he/she has the rights to create an asset i.e if he/she is a manufacturer and third is to cross-check whether a product with similar attributes have already been deployed on the blockchain by the user.If the third condition is true, then the new asset quantity will be added to the existing product. If all the conditions are found to be false then a hash key

consisting of a random integer, manufacturer details, and asset details will be generated using Keccak256 hash technique provided by solidity. This key will then be used for generating a QR Code which could be verified by other entities in the supply chain. Here, then in the "Identity Store" map a mapping is created which will map the Owner with the newly created Asset object.
The transfer Ownership() function in the smart contract is called every time a user wishes to transfer the product to the next entity in the supply chain. A series of checks were performed like
a. if the user account exists or not
b. if the next member to whom the product is being transferred is the owner of the product
c. if the asset which is to be transferred exists or not
d. if the receiver account exists or not

Here, if all the checks are passed, then we get the "asset id" from "Asset Store" of the asset which is to be transferred and then check whether
a. Person initiating transfer is the sender or not
b. Is the product genuine
c. Is the product verified

Here, if all checks are passed then we delete then the product is deleted from the sender's "Identity Store" and the same product is added in the receiver's "Identity Store" with the "is Verified" flag being set as false for initiating checks when another transfer and sell event happens.. Then the "owner Address" is changed for the Asset. On, this transfer event when the next member in the supply chain receives the product then the receiver verifies the product by the help of QR code sent wherein the key is matched and on successful verification the receiver sets the is Verified flag as true and then he/she can further transfer the product to next member.

The sell To End Customer() function first of all performs the following checks
a. if the user account exists or not
b. If the asset which is to be sent to End Customer exists or not.
c. If the user is a retailer or not as in our supply chain only retailer has the ability to transfer the product to End Customer.

If all the checks are passed then, the product details are deleted from the blockchain

C. How frontend reacts with blockchain
Users first of all login to their account. Here, the user's entered password is hashed with Keecak256 and then it is matched with the stored Keccak256 hash value of the user's password for the same email. On successful login, the user can then wish to add a product if he/she is a manufacturer or transfer the product or verify the received product
Here, if a manufacturer wants to add a new product to the blockchain, then he clicks on the Add Product button and then a form is displayed wherein the manufacturer fills all the required fields. Then, the user needs to pay the gas fee for the operation to be done on blockchain through his/her Metamask wallet account and after successful payment web3js interface sends the details in the form to the blockchain. in the blockchain.
For transferring the product, users click on the Transfer button and then they fill the required fields. Then, the user needs to pay the gas fee for the operation to be done on blockchain through his/her Metamask wallet account and after successful payment and after this the ownership of the product is changed with the help of web3JS interface which interacts with blockchain.

In the process of Verifying the product, users click on the Verify button where they have to submit the QR Code and the user needs to pay the gas fee for the operation to be done on blockchain through his/her Metamask wallet account and after successful payment the QR code key is sent by web3js interface to the blockchain and then the keys are matched. Here, on successful matching of the QR code which was generated by the help of a 256 bit hash key the product is verified successfully. In the application, if any party wants to track a particular product then they click on the Track Product button for the respective product which is to be tracked, and then all the tracking details are displayed to the desired party.

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D.. Experimental Results

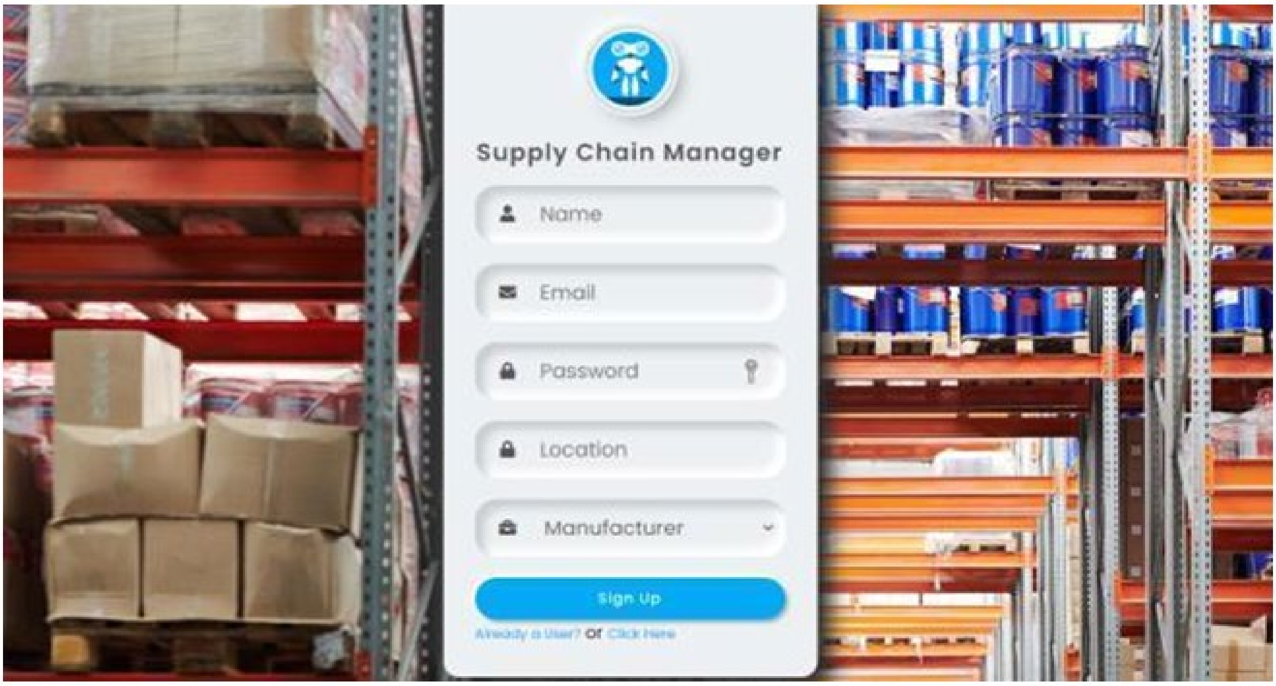

Fig 5. Signup Page

Fig 5.displays the Signup page where the user fills the name, email, password, their role in the supply chain and their location. Here, while signing up the metamask account gets stored for the user.

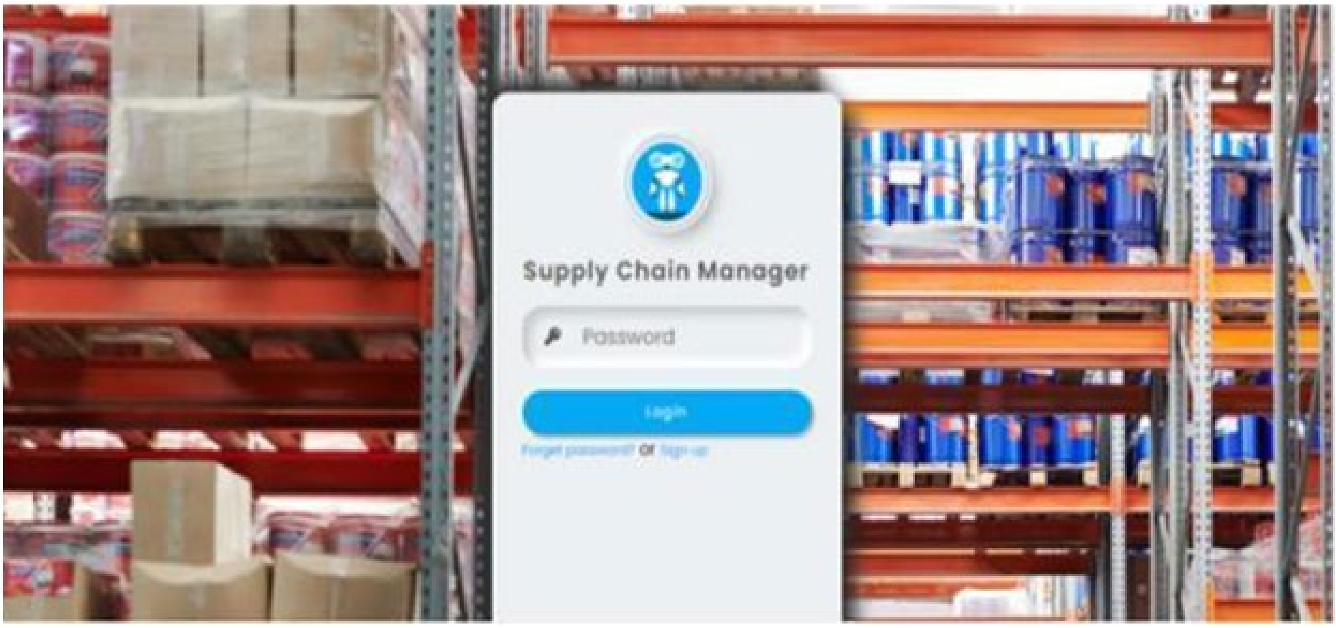

Fig 6. Login Page

Fig 6,displays the Login page where the user fills the password to login. Also, here the user must be accessing the page from the same metamask account as he registered.

Fig 7. shows the Create Product page where the manufacturer adds a new product onto the blockchain.

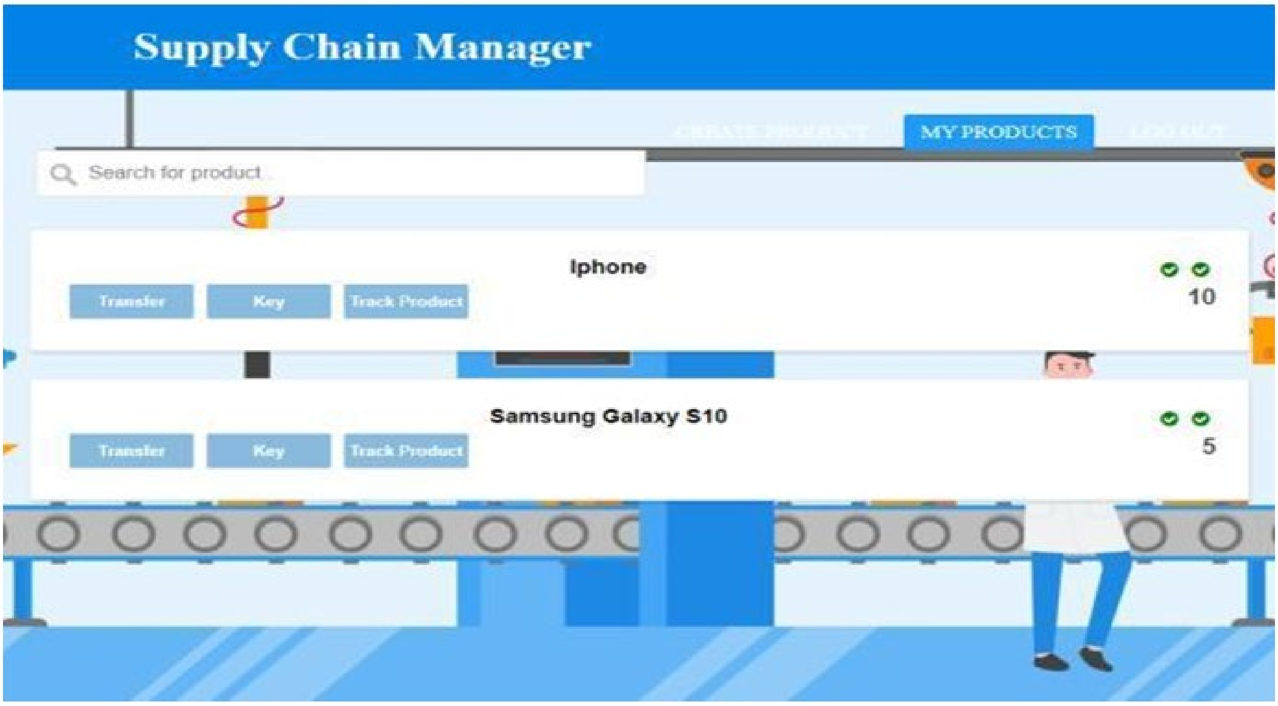

Fig 8. My Products

Fig 8. displays the My Products page where the user can see the products owned by him/her or are in the transferring process. Here, each product provides the functionality of Transfer, getting the Key, and Track Product for the manufacturer. while for any other user there is a Verify button instead of Key.

V. RESULT

Flow of fake products has exponentially increased in the market in recent years. These products sometimes appear to be so identical to the original counterpart that even an experienced person couldn't distinguish the two. An application which could help manufacturers and other entities in the supply chain to track the products location and condition in real time as well as well identify the origin of introduction of fake products in the chain was required. As a result, blockchain technology based solutions which would act as a data store against the traditional SQL databases, restrict data tampering which in turn would help in fake product identification at different points in the supply chain using QR-Code and OTP Verification was implemented.

TABLE I
GOALS ACHIEVED

Goals	Parameters
Remove hardware dependency	● No dependency on GPS systems ● Avoided usage of RFIDs ● Independent of battery
Make the system cost efficient	● Manual intervention is not required ● Recharging hardware not required ● Low cost of transactions
Make the system user friendly	● No requirement of peripheral processes ● "One-Click" based features ● On par with blockchain based systems
Make the data immutable	● Asset verification is done by QR code generation ● Records stored in blockchain are immutable to avoid tampering
Traceable records	● Transactions that are recorded can be traced back to their source ● Supports fault tolerance in case of any conflicts

Peers were asked to review the system in order to judge its usability and reliability. 15 peers used the system simultaneously while assuming various identities. The responses provided confirmed the system's value. To check the originality of the concept and level of understanding demonstrated, a working video and an abstract outlining the system's functionalities were sent to a second group of 10 people. It was made sure to include peers who are not familiar with blockchain systems when choosing the peer group.

VI. CONCLUSION

In this project, Supply Chain Management using Web3 Framework and Blockchain Technology was performed. Loopholes like identification of Fake Product between different entities in the chain, Unauthorized Data Tampering which was possible in traditional SQL Database based application was resolved by using the concept of Blockchain and Smart Contracts which discourages malicious activities by making the unauthorized user do high computationally intensive task that in turn results in huge investment of time and money making it infeasible.

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