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# Supply Chain Visibility Using Blockchain

Rushabh Timbadia[1], Suraj Pawar[2], Riken Shah[3] and Bhavna Arora[4]
[1][2][3] *Student, Department of Computer Engineering, University of Mumbai, Atharva College of Engineering, Malad, Mumbai, India*
[4] *Assistant Professor, Department of Computer Engineering, University of Mumbai, Atharva College of Engineering, Malad, Mumbai, India*

***Abstract***
*A supply network is a very intricate chain of numerous exchanges between different organizations involved and has developed over a very long period of time. And the introduction of e-commerce has also increased the demands of the supply chain in the past few years. There are many malpractices in this industry such as shipping of fake or used products, tampering with MRP. In the food and beverage industry, regulations, labeling standards, and audits make trace-ability amendatory objective. But in some industries due to the nature of its products and customer consumption patterns, supply chain pro0duct traceability is a low priority, for example, the apparel industry. To tackle this problem, we propose a system where the information regarding the supplier, product, and customer will be collected using the blockchain technology. Blockchain technology will be used for this system to record the entity(s) involved in the supply of products from the supplier to the customer into an immutable ledger so as to keep a permanent record of the transaction. For this system, a virtual Ethereum blockchain will be used using the software Ganache, and the interaction with the blockchain will be done using the web3.js library and Truffle framework. A smart contract will validate and carry out all the transactions that take place between the entities.*
***Keywords:*** *Blockchain, Distributed Network, Smart Contract, Hash Function, Supply Chain Visibility, Ganache*

## 1. Introduction

Supply chains around the world handle the manufacturing and transportation of millions of products on a daily basis. E-commerce has introduced the populace to a global market which was not possible without the internet and this has led to the dramatic increase in the magnitude of transactions in the supply chain between different entities from suppliers to customers. But there is almost no understanding of how, when, and where these products emerged, fabricated and handled via these supply chains. Before reaching the final consumer, the goods pass via multiple networks of retailers, distributors, transportation providers and provisioners who take part in production and distribution, yet in most of these cases these transfers are not seen to us. There are many cases of malpractices in various industries such as shipping of wrong products or empty boxes, tampering with MRP, and the most common one that is selling fake or used products. Due to this, as a matter of risk prevention and consumer/labor protection, there is an increased demand for transparency in supply chains. Supply chain visibility also presents itself as a major challenge in businesses, with majority of organizations and companies having very little to no information on their own second and third-tier provisioners. Management and control of information data and transparent interactions for every product's supply chain can be a really troublesome task and this responsibility is taken up by non-profit, governmental organizations through centralized data depositories. Trusting one organization to broker such valuable and sensitive information needs tremendous amount of trust to be invested by each actor within the supply chain. In addition, these non-profit organizations will also gain influential power through the ownership of this valuable information, which can be misused to deface or damage the organizations if they are biased. Even though the data is securely stored by big companies involved in the supply chain, there are numerous small actors involved in the supply chain which at most store their daily transaction details in a centralized database, without any backup and bare minimum protection, which in case of an external malicious attack or an untimely crash or corruption of the database system, the small companies risk losing all their past transaction and future orders, which can be fatal to the operability of the company. On the economic front, lack of visibility can lead to challenges such as Information asymmetry and double

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marginalization. Information barriers between different vertical levels can lead to the addition of many hidden costs, and a result overcharging of products in the supply chain.

The blockchain technology discussed above can solve most of the problems by providing an immutable, distributed, and transparent ledger to record all the transactions between the actors involved in the supply chain.

## 2. Why Blockchain for Supply Chain?

The process of linking each new block of transaction to its preceding block in a way that makes tampering/meddling almost impossible is what makes the ledger so secure. Because of the ledger being localized it does not depend on any single organization (for example: a bank) for preservation. The nodes connected to the blockchain network gets updated versions of the ledger every time a new transaction takes place. The multiple number of copies of the ledger prove that every transaction made so far in the blockchain are "authentic". Any attempt to counterfeit or alter would mean one would have to tamper or meddle with all the copies of the ledger and that too at the same time. The likeliness of that happening are next to zero.

## 3. Background Technologies Used

### 3.1 Ganache Software

Ganache is a first-hand blockchain software for the development of Ethereum which can be used for creation of various contracts, development of applications and running tests. It is available as a desktop application as well as a CMD. It can work on all operating systems.

### 3.2 RFID Technology

Radio-frequency identification (RFID) is a technology that is employed to mechanically identify and track tags of the item it is attached to using electro-magnetic force fields. An RFID tag consists of a tiny radio receiving system, a radio transponder and transmitter. It transmits digital information, typically an identifying inventory number, back to the reader once it is triggered by an electromagnetic pulse from a close-by RFID reader. There are 2 sorts of RFID. Passive tags and Active tags.

### 3.3 What is Ethereum (ETH)?

Ethereum is an open source platform that permits developers to create and deploy localized applications like smart contracts and other advanced legal and monetary applications. One can think of Ethereum as Bitcoin but which can be programmable, where developers/creators can make use of existing blockchain technology to create markets, digital organizations, ledgers, and plenty of alternative things that require immutable information data and agreements, all without the indulgence of a middleman. It was released in 2015, by VitalikButerin, who saw potential in the uses of Bitcoin's blockchain technology. Ethereum is currently the second highest crypto currency market capital and is assumed to overtake Bitcoin as the world's most popular cryptocurrency.

### 3.4 What is Metamask and why is it important?

Metamask is a plug-in that is used to facilitate Ethereum transactions via regular websites. It acts as a bridge for the Ethereum's user interfaces and the regular web, thus facilitating the adoption of Ethereum. Without this, Ethereum cannot become mainstream due to the strong network presence which the regular web has on the average users inhibiting them from switching.

## 4. Literature Review

A number of pre-existing literatures on Supply Chain Networks and use of Blockchain technology has been studied.

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The same is summarized below.

The paper on 'Bitcoin: A peer-to-peer electronic cash system' [1] presents a system in which there is no trusted third party involved to oversee the transaction of money from one person to another. In this framework, the transaction details are stored in entities known as a block and these are chained to each other serially, using the concept of hashing. Every peer involved in the network has a copy of the blockchain to verify the authenticity of the blockchain. If any information data stored in a blockchain does not match with those stored on other nodes the data is reverted to the data similar to the majority of nodes.

The main aim of Abeyratne et. al. in their paper [2] is to discuss all the aspects of implementing the blockchain technology in the supply network management system from potential benefits of the technology, the vision, and also the challenges of this technology in the field. There are millions and billions of goods being put on daily worldwide, through a network of compound supply chains that expand to all parts of the globe. The author further proposes an approach that comprises of a localized distribution system that uses blockchain(s) to store and manage essential information of each product throughout its life cycle.

The authors Korpel et. al. in their paper [3] trying to create a system in which there is traceability of Product involved in the foreign transaction or state transaction to avoid the misplaced product it protects the consumer from fraudby applying an extra charge of traveling product travelling. Traceability involves identification of units, registration of information on when and where units are moved, transfer traceability information with the product to processing steps. The author claims that the transactions stored in the peer to peer network are tamperproof, cannot be altered by an attacker and the identity of all the parties involved in transactions is secure and all the process of transaction seen by the customer.

Haoyan Wu et al. in their paper [4] created a system in which there is traceability of products involved in the foreign transaction or state transaction to avoid the misplaced product, protect the consumer from fraud by applying an extra charge of traveling. It involves identification of units, registration of information on when and where units are moved, and a system link these data and transfer traceability information with the product to processing steps. Recognizability frameworks are utilized as record-keeping frameworks that show the way of a specific item from providers through middle of the road steps to customers.

The authors Hasan et. al. in their paper [5] talk about a general structure utilizing the renowned Ethereum blockchain technology to employ a trusted, localized PoD system that ensures responsibility, auditability and authenticity assets. Hence the writer uses blockchain technology for physical assets. In future the authors are trying to find the answer to PoD of digital assets, to ensure localization, trusted and safe delivery and mechanized payment for all types of traded assets be it virtual or real.

The authors X. Xu et. al. in their paper [6] suggest a taxonomy that seizes major design features of blockchains technology and its impact on their primary architectural decisions. The author has carried out an extensive study on blockchain technology and provided a classification on the basis of multiple factors such as cost efficiency, performance, flexibility, privacy, the scope of the blockchain, scalability, consensus protocol etc.

The paper "Information Sharing for Supply Chain Management based on Block-chain Technology" written by M.Nakasumi [7], addresses the economic issues of the supply network such as Double Marginalization and Data Asymmetry, etc., using Blockchain Technology. In the system proposed by the author, it has two organizations comprising their system. One is the institution that is focused on building a supply network while other is the blockchain node. The organizations tasked with taking care of the blockchain technology and a distributed public/private protected information stored in exchange for incentives.

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Feng Tian suggests in her paper, [8] an agricultural network of supply chain traceability system to ensure food quality and safety simultaneously, to highly reduce the losses during the planning process. Foodstuff security has befallen a trouble as the customary agricultural logistics prototype cannot contest the demands of the marketplace. The author has used RFID technology and blockchain technology to maintain the transparency and quality of the food supply network. RFID tags are primarily used on the packaging, which stores various kinds of data on agricultural products such as the name, variety and another parameter of the product along with the information of manufacturing managers and operational staff. All information stored in RFID tags is saved in the blockchain system.

The paper 'On the Integration of Event-Based and Transaction-Based Architectures for supply chains [9], suggests a solution to solve two important problems in the distribution phase of the supply network, namely economic feasibility and transparency of truckload activities by using blockchain technology. The author focuses on addressing the real-time transparency issue in the physical distribution phase of supply network and suggests a digital model that incorporates a distributed event-based system with the traditional transaction-based system.

The authors 'Wang, S., Ouyang, L., Yuan Y., Ni, X., Han, X. and Wang, F. Y' [10] try to show how Smart Contracts are providing helpful guidance, how they help to achieve security through Ethereum Blockchain and how they aim to provide a reference for future research efforts.

The authors 'Zheng, Z., Xie, S., Dai, H., Chen, X., Wang H.' [11] presents a thorough summary on the blockchain by giving an outline of the blockchain technologies including blockchain design and key features of blockchain technology alongside the discussion of the typical consensus algorithms utilized in the blockchain technology.

The authors Li Zhijie et. al. in their paper [12] suggests a system wherein which peer-to-peer design can support the rising demand for visibility and timely delivery of information data throughout the physical distribution phase of the supply network. The author suggests a new application of blockchain technology in the design of hybrid peer-to-peer physical distribution.

## 5. System Description

The users who use the website require a Metamask Account. If the users are owners of Metamask Wallets and are first time users, they will be asked to register themselves to the website. If the users have already registered themselves, they are redirected to their respective webpages. The above figure shows the way in which the system works. There are three entities present: -

- Buyer- include Customer, Retailer, Manufacturer, Distributor
- Seller- include Retailer, Manufacturer, Distributor, Supplier
- Smart Contract

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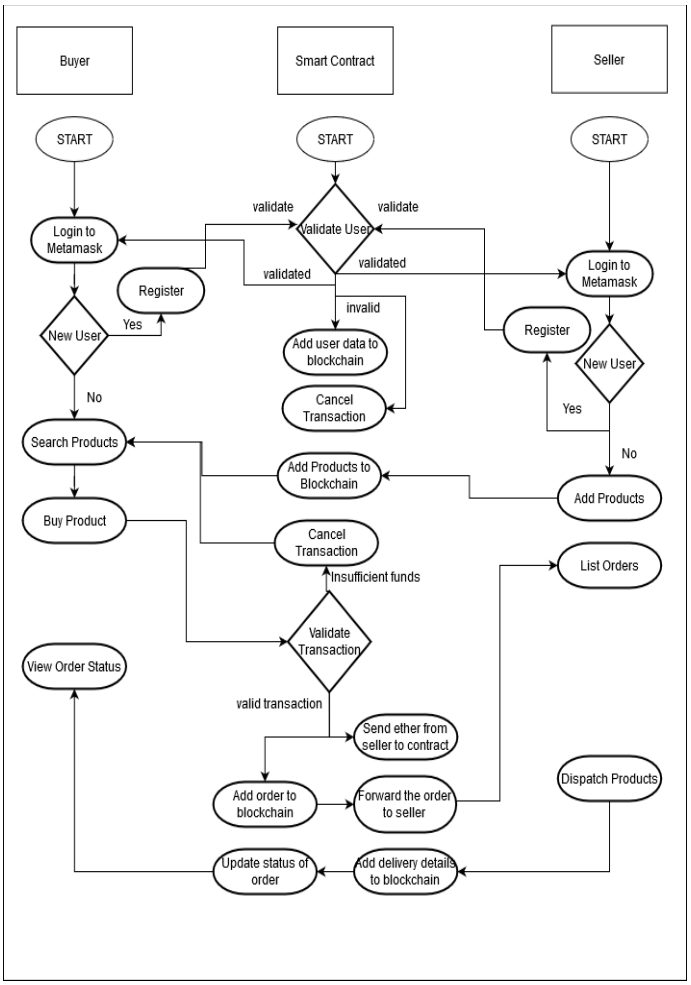


**Figure 1. Flow of The System**

A user can register themselves in five types of user accounts
-Customer, Retailer, Manufacturer, Distributor, and Supplier.

Customers refer to the end-users who will be buying the finished product from the website. But a registered customer account cannot carry out the sale of any product via the website. The customers will be able to buy products listed by retailers or distributors.

Retailer accounts are the ones that will carry out the purchase for distributors and sell the products to customers. Distributor accounts will be the ones to sell directly to the customer or retailers and can only purchase from the manufacturer.

Manufacturers' accounts will be able to buy from suppliers and sell to distributors. The supplier accounts can only conduct the sale of their products on the platform and cannot buy any product from any other user. A customer may not require verification, but all other actors will require verification to carry out the sale and purchase products on the platform.

## 6. Implementation

The system will have multiple actors' users using the platform, and hence a mapping is created named users (address => User), where User is a struct storing information such as role, location address, etc. Similarly, two more mappings are created for products (unit => Product) and orders (unit => Orders). When the user accesses the website the 'role' variable of struct 'User' is mapped to a registered address is verified and a particular webpage or information is loaded. As mentioned before, there is a restriction on what a

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user can buy and sell according to their user accounts. The smart contract has various functions, to carry out validation and execution of the transaction. When a seller adds a batch of product, all the details of the batch of products is verified by the smart contract and then if successful, stored into the 'products' mapping using productCreate() function. Once the product is stored in the blockchain, it will be listed for the buyers to buy the product.

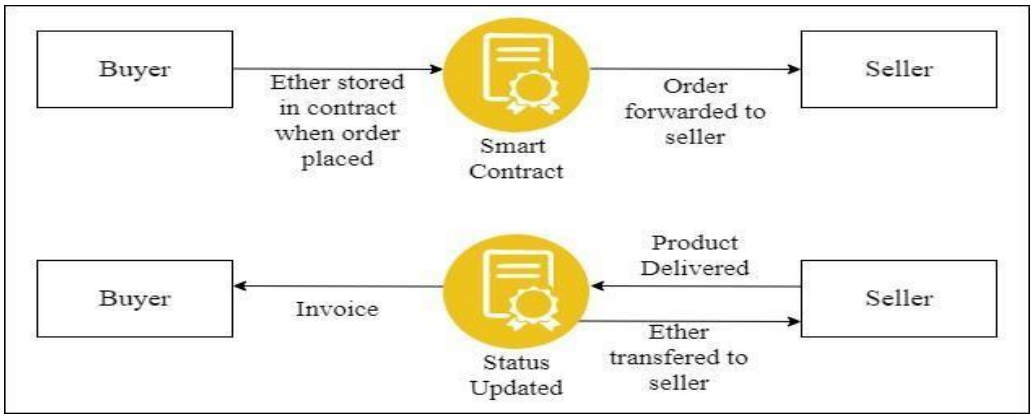


**Figure 2. Payment of Products**

As shown in the figure, when the seller buys the product, the purchaseProduct() function is initiated. The function consists of checking whether the buyer has enough ether in his wallet and other requirements. Once the verification is successful, the order details are stored in the Struct array for orders. Then, the ether from user accounts is deducted and added to the smart contract's balance, the order transaction details are stored in the blockchain and then forwarded to the respective seller. So, when the seller loads the list of orders, the order will be visible on the list.

When the seller has completed the delivery of the product, only then, the ether stored in the smart contract is released to the seller.

The system uses a local virtual blockchain known as Ganache. The interaction with the Ethereum blockchain is done using the web3.js library, and the front end is designed using React.js.

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## 7. Results

The following table represents the advantages of introducing blockchain technology in the supply chain:

| Features of Supply Chain | Without Block chain | Using Block chain |
|---|---|---|
| Origin Tracking | Very difficult due to unreliable sources | Product origin data is stored in an immutable storage |
| Cost Reduction | Cost of manufacturing and shipping can be tampered with | Costs cannot be tampered, as well as hidden costs can be avoided |
| Transparency | Information can be hidden or manipulated | Information cannot be manipulated |
| Security | Less secure, since data is stored on the database there will be chances that the system will be exploited by some attacks | Highly secured because the data that is stored in the blocks are encrypted |

**Table 1. The Benefits of Block-chain**

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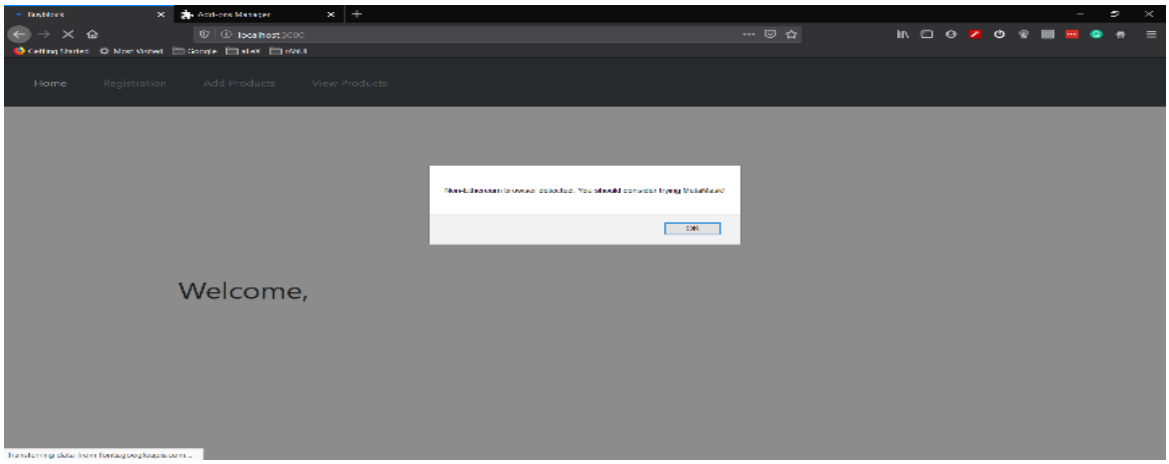


The basic operation of adding products to the blockchain by the seller is showcase in the following screenshots:

**Figure 3. Metamask Not Installed**

The above figure shows the error message to the users which ask the user to install metamask if it is not installed in the user's browser.

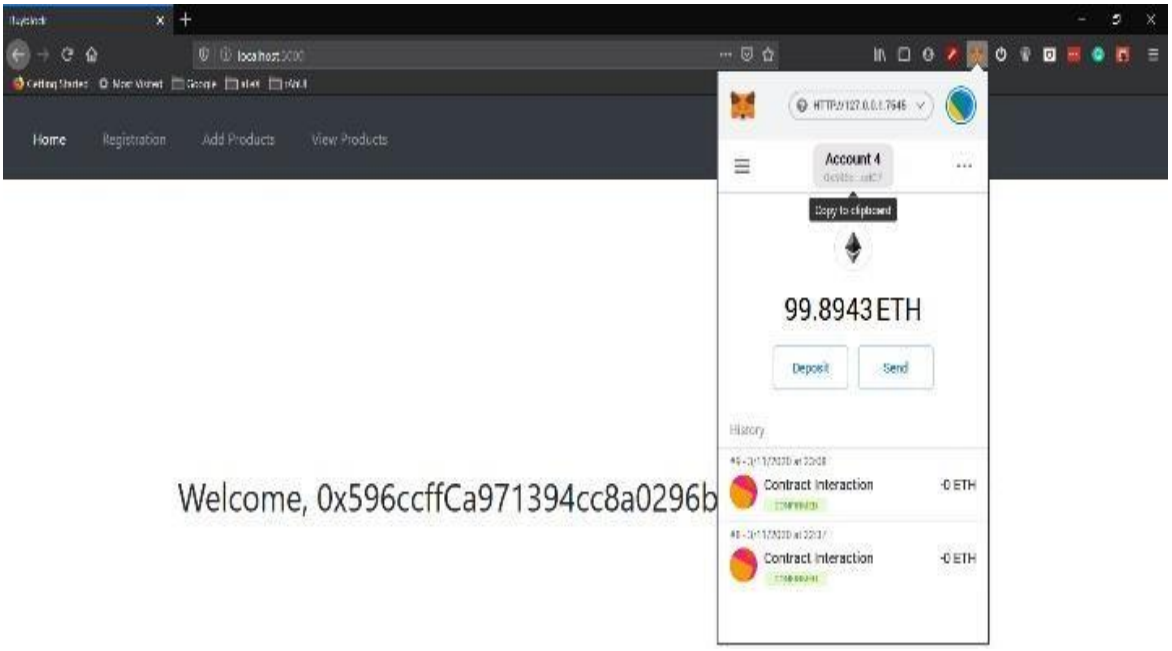


**Figure 4. Home Screen**

The above figure is the home screen which displays a welcome message with the user's metamask account.

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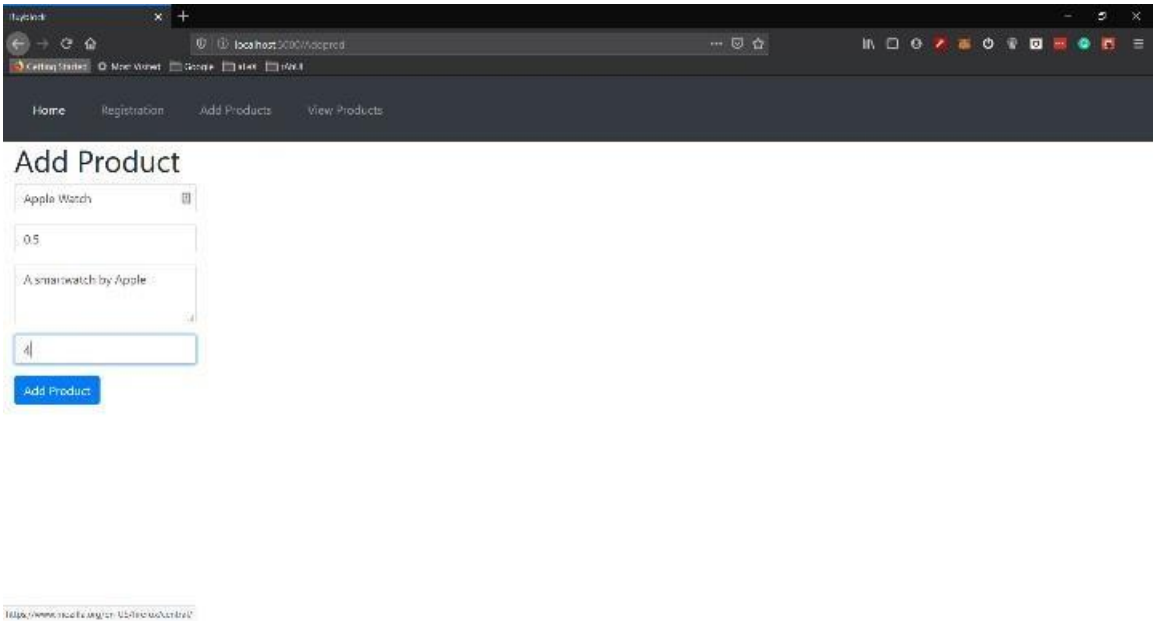


**Figure 5. Add Product**

The above figure shows the Add Product form that the supplier needs to fill. The data is filled by the supplier is stored in a blockchain.

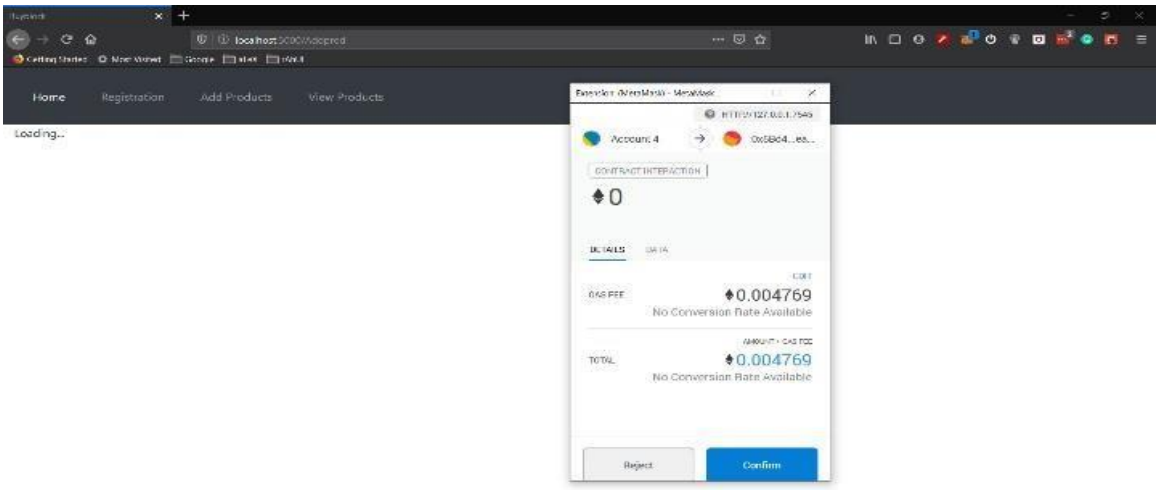


**Figure 6. Metamask Add Product**

After filling the form, the supplier gets connected to metamask, a small amount of gas fee is paid to complete the transaction.

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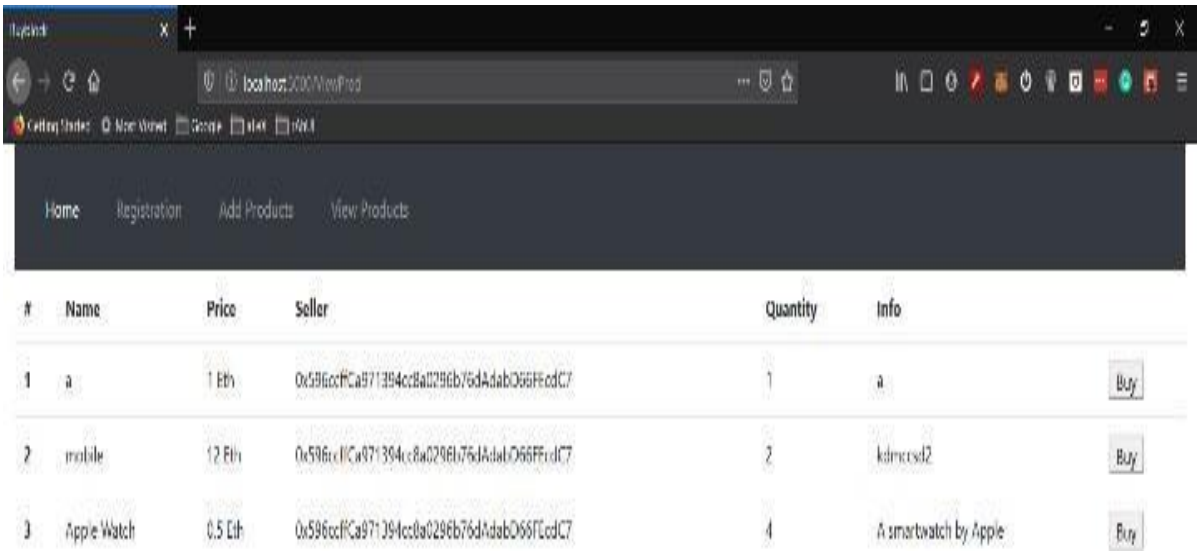


**Figure 7. View Products**

The above figure shows the lists of products which are added by the supplier along with its metamask account. The customer can buy the product by clicking on the buy button.

## 8. Conclusion

This system is made with the objective to keep permanent records of transactions taking place in the supply network. The data related to products, suppliers, and customers will be kept in the blockchain. The system will reduce the influx of fake products and will also create an immutable record of the transaction, which will prevent the supplier from denying responsibility in case of any unfair trade practice. The blockchain will bring in transparency on different levels of the supply chain. This will prevent overpricing of the products as well as provide a standard for product prices without revealing the details of the entities involved in the transactions. Hence, a coexistence of confidentiality and transparency in the supply network is possible with the help of blockchain technology.

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