Supply Chain Visibility using Blockchain

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***Abstract*—A supply chain is a very complex network of multiple exchanges between different entities 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 a mandatory objective. But in some industries due to the nature of its products and customer consumption patterns, supply chain product 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 stored using blockchain technology. This system will use Blockchain technology 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**

I. 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 contributed to the dramatic increase in the volume of transactions in the supply chain between different entities from suppliers to customers. However, there is very little to no knowledge of where, when, and how these products originated, manufactured and handled through these supply chains. Before reaching the final consumer, the goods pass through a vast network of retailers, distributors, transporters, and suppliers who participate in production and distribution, yet in almost every case these journeys are an unseen dimension 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. The problems mentioned earlier, have forced through a demand for transparency in supply chains as a matter of risk prevention and consumer/labor protection. Supply chain visibility also presents itself as a key business challenge, with most companies having little or no information on their own second and third-tier suppliers. Managing information and control of transparent interactions about every product's supply chain can be a very difficult task and this responsibility is taken by non-profit, governmental entities through centralized information depositories. Trusting a single organization to broker such sensitive and valuable information requires a great deal of trust to be invested by each actor in the supply chain. In addition, these non-profit organizations will also gain significant power through the possession of this valuable data, which can be misused to extract or harm organizations if they are biased.

Even if data is securely stored by big companies involved in the supply chain, there are many 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 marginalization. Information barriers between different vertical levels in the supply chain can lead to the addition of many hidden costs, and a result overcharging of products.

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

II. LITERATURE REVIEW

A number of existing literature on Supply Chain and use of Blockchain technology has been studied. The same is summarized below.

The paper 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 credibility of the blockchain. If any information 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.

Haoyan Wu et al. in their paper [2] 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. Traceability systems are used as record-keeping systems that show the path of a particular product from suppliers through intermediate steps to consumers.

The paper 'On the Integration of Event-Based and Transaction-Based Architectures for supply chains [3], suggests a solution to solve two key issues in the distribution phase of the supply chain, namely affordability and pseudo-real-time visibility of truckload activities by using blockchain technology. The author focuses on addressing the issue of real-time transparency in the physical distribution phase of the supply chain and proposes a digital model that integrates a distributed event-based system with the traditional transaction-based system.

The main aim of Abeyratne et. al. in their paper [4] is to discuss all the aspects of implementing the blockchain technology in the supply chain management system from-potential benefits of the technology (such as transparency and traceability in the supply chain), the vision, and also the challenges of this technology in the field. There are billions of products being manufactured every day globally, through complex supply chains that extend to all parts of the world. The author further proposes an approach that comprises of a decentralized distributed system that uses blockchain(s) to collect, store and manage key product information of each product throughout its life cycle.

The paper "Information Sharing for Supply Chain Management based on Blockchain Technology" by M. Nakasumi [5], addresses the economic problems of the supply chain such as Double Marginalization and Information Asymmetry, etc, using Blockchain Technology. In the system proposed by the author, there are two entities comprising their system. One is the company that is interested in building a supply chain and another is the blockchain node. The entities entrusted with maintaining the blockchain and a distributed public/private protected data store in return for incentives.

Feng Tian suggests in her paper[6] an agri-food supply chain traceability system to enhance food safety and quality at the same time, to significantly reduce the losses during the logistics process. Food safety has become a problem as the traditional agri-food logistics pattern cannot match the demands of the market. The author has used RFID and blockchain technology to maintain the transparency and quality of the food supply chain. RFID tags are mainly used on the packaging, which saves many kinds of information on agri-food products such as the name, variety and another parameter of the product along with the information of production managers and operational staff. All information stored in RFID tags is saved in the blockchain system.

The authors X. Xu et. al. in their paper [7] suggest a taxonomy that captures major architectural characteristics of blockchains and the impact of their principal design 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 authors Hasan et. al. in their paper [8] talk about a general framework using the popular Ethereum blockchain to create a trusted, decentralized PoD system that ensures accountability, auditability and integrity assets. Hence the author uses blockchain technology in physical assets. In future the authors are trying to find the solution for Proof of delivery of digital assets (such as online books, documents, photos, movies, music, etc.), to ensure decentralized, trusted and secure delivery and automated payment for all types of traded assets whether they are physical or digital.

The authors Korpel et. al. in their paper [9] 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 fraud by 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.

The authors Li Zhijie et. al. in their paper [10] suggests a system in which peer-to-peer architecture that can support the increasing demand for visibility and timely delivery of information during the physical distribution phase of the supply chain. The author proposes a new application of blockchain technology in the architecture of the hybrid peer-to-peer physical distribution (HP3D).

The authors Zheng, Z., Xie, S., Dai, H., Chen, X., Wang, H. [11] presents a comprehensive overview on the blockchain by giving an overview of blockchain technologies including blockchain architecture and key characteristics of blockchain along with a discussion of the typical consensus algorithms used in blockchain.

The authors 'Wang,S.,Ouyang,L.,Yuan,Y., Ni, X.,Han,X.and Wang,F. Y.' [12] 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.

III. 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

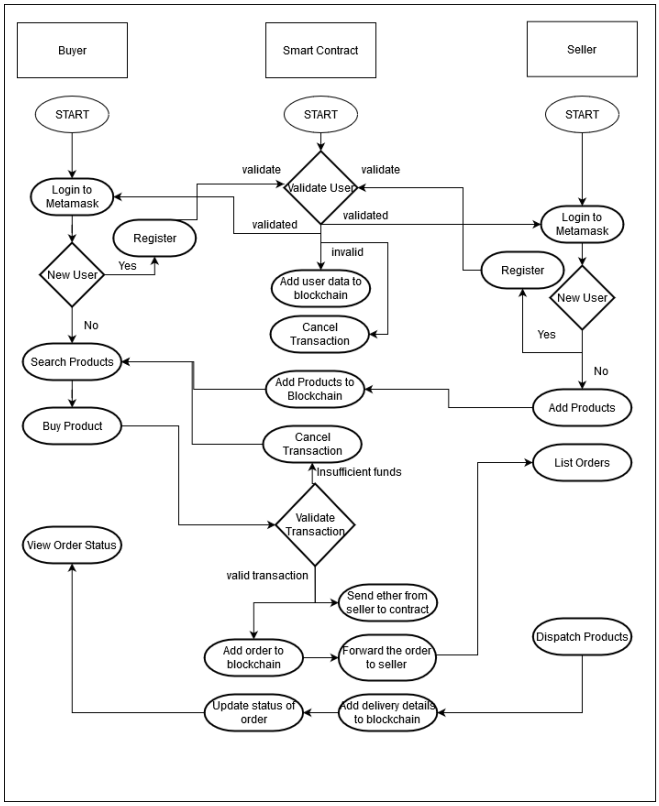

Fig. 1: Flow of the system

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 able to sell directly to the customer or to the 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.

IV. 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 (uint => Product) and orders(uint => 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 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.

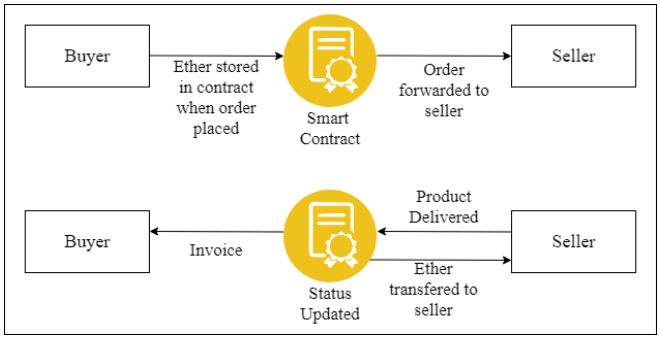

Fig. 2: Payment of products

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.

V. RESULTS

TABLE I

The following table presents the benefits of introducing blockchain in the supply chain:

Features of Supply Chain	Without Blockchain	Using Blockchain
Origin Tracking	Very difficult due to unreliable	Product origin data is stored in

	sources	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

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

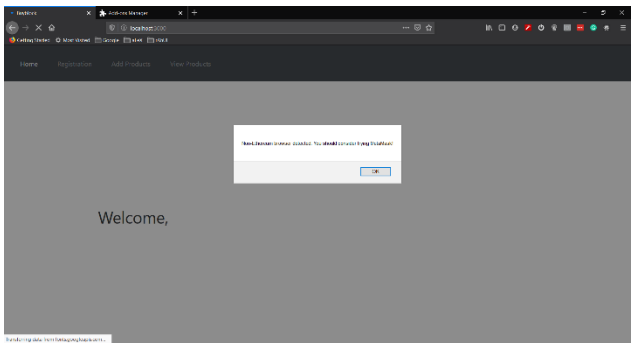

Fig. 3: Metamask not installed

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.

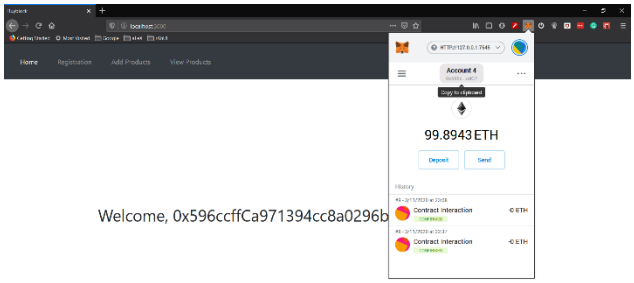

Fig. 4: Home Screen

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

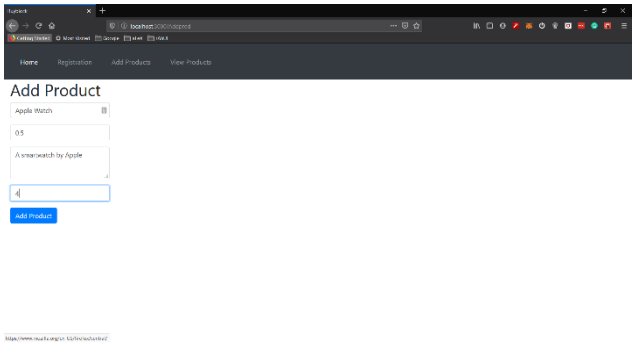

Fig. 5: Add Product

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.

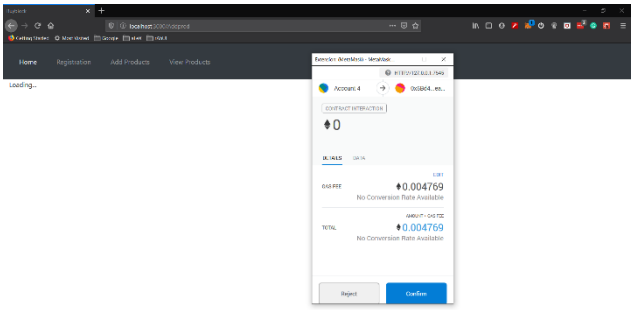

Fig. 6: Metamask add product

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

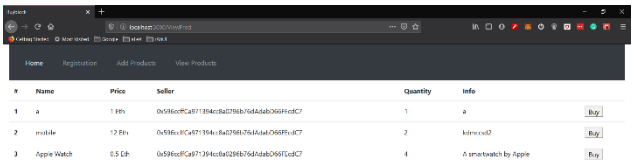

Fig. 7: View Products

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

VI. CONCLUSION

This system is made with the objective to keep permanent records of transactions taking place in the supply chain. The information related to products, suppliers, and customers will be stored in a 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 parties involved in the transactions. Hence, a coexistence of transparency and confidentiality in the supply chain is possible with the help of blockchain.

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