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SYSTEM DESIGN AND IMPLEMENTATION OF DRUG SUPPLY CHAIN MANAGEMENT USING BLOCKCHAIN

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ABSTRACT

Blockchain has gotten a lot of attention recently, and there are a lot of applications that have come out of it. A blockchain is a distributed database of records, or public ledger, of all transactions or digital events that have been completed and shared among participants. Every transaction in the public ledger is double-checked by a majority of the system's members. Information can't be deleted after it's been entered. Every transaction done is recorded in the blockchain, which is definite and provable. The most well-known example of blockchain technology in practice is Bitcoin, a decentralized peer-to-peer digital money. The primary idea is that the blockchain creates a means for achieving distributed consensus in the digital online environment. By producing an irrefutable record in a public ledger, involved entities may be assured that a digital event took place. It makes it possible to transition from a centralized to a democratic, open, and scalable digital economy. Ethereum is a decentralized blockchain technology that creates a peer-to-peer network for securely executing and verifying smart contract code. Smart contracts enable parties to transact with one another without the need for a trusted central authority. Transaction records are immutable, verifiable, and securely distributed over the network, providing participants with complete ownership and insight into transaction data. This initiative uses the Ethereum blockchain to control the medication supply chain. Drug supply chains are complex networks that transcend various geographical boundaries, serving as the backbone for basics needed in everyday life. Our primary goal is to minimize the supply of counterfeit drugs. This project enables enhanced traceability of the medication supply chain to ensure corporate requirements are maintained, reduces losses from counterfeit pharmaceuticals, and eliminates the time-consuming paperwork required to manage total transactions. It also makes it easier for the client to check the product's integrity.

Keywords: Blockchain, Ethereum, Smart-contract, Supply chain, Decentralization.

I. INTRODUCTION

The advancement and deployment of blockchain technology has raised fresh expectations for the resolution of numerous types of challenges. Blockchain technology offers the benefits of decentralization and distributed storage, as well as anti-tampering and more dependable and secure storage. And these benefits are particularly well suited to the objectives of pharma supply chain management. Blockchain is a data format that connects data blocks in chronological order in a chain. Data is permanently kept in the form of blocks in blockchain technology. Each block is created chronologically and linked to build a block chain using a chain structure. Each block is made up of two parts: a block header and a block body. The version number, timestamp, hash value of the preceding block, and important data participating in the consensus mechanism are mostly contained in the block header. The preceding block's hash value is a hash operation on the data of each module that goes to the block header, and the blocks are linked by this hash value. From the establishment of the blockchain till the development of this block, the block body stores all transaction data. The blockchain is also a distributed decentralized database. The typical distributed database has just one central server to maintain data, but the blockchain network is maintained by all nodes. Every node will create a backup. If a single node's data is tampered with or deleted, it has no effect on the data recorded in the blockchain.

II. SYSTEM DESIGN

Basic model

As shown in fig 1, this project design includes different login pages for Consumer, Manufacturer, Distributor, Retailer and Raw Material Supplier. When a manufacturer first registers on the website, they must supply several facts and proofs, such as the name of the manufacturing company, its address, phone number, and a

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government-verified license, among other things. They will receive a verification email once their credentials have been validated. Then, in an excel format, they must include information such as total supply of medicines, medicine name, dosage of medicines supplied, manufacturing date of medicines, and expiry date of medicines. From the excel sheet, the system will generate a QR code, which can be downloaded from the website. These QR codes are affixed to the medicines that will be distributed by the producers.

When a supplier related or linked to a specific manufacturer register on the website, they will be required to fill out information such as Supplier Name, Supplying Company Name, Address, Phone Number, and Government Verified License. When a supplier receives medicines from a manufacturer, he must scan or upload the QR code on the medicine supply. He will be able to tell whether the pills he received are genuine or not. Similarly, the consumer can create an account on the website and verify the medicine's authenticity by uploading or scanning the QR Code image seen on the medicine. All data pertaining to the supply chain is stored in a blockchain database. Consumer, manufacturer, and supplier are the actors on this blockchain. The addresses of data are collected and loaded into the metamask, and the transaction is checked, using local blockchain ganache. Traceability, security, and serializability are all preserved with the following procedure.

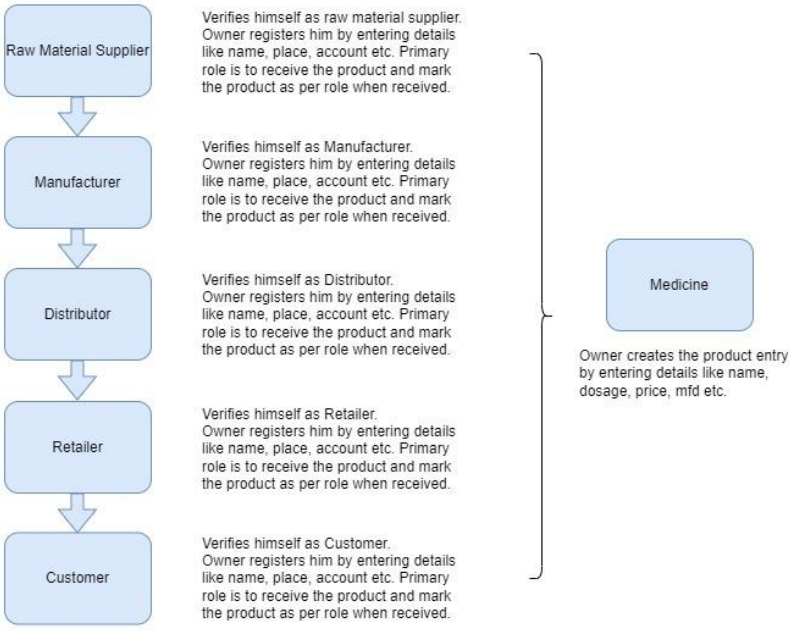

Figure 1: Complete buying process

Metamask

Metamask is a tool that allows users to manage their accounts and keys in a variety of methods, including hardware wallets, while keeping them separate from the site's context. It is a browser plugin that acts as an Ethereum wallet and can be installed in the same way as any other plugin. It allows users to store Ether and other ERC-20 tokens and perform transactions to any Ethereum address once it's installed. Through a suitable web browser or the mobile app's built-in browser, MetaMask allows users to save and manage account keys, broadcast transactions, transfer and receive Ethereum-based coins and tokens, and securely connect to decentralized applications. As seen in fig 2, this is utilized to interface with decentralized applications.

Smart Contract

Simply said, a "smart contract" is a software that runs on Ethereum's blockchain. It's a collection of code (its functions) and data (its state) that lives on the Ethereum blockchain at a single address. Ethereum accounts come in the form of smart contracts. This indicates that they have a balance and are able to send transactions across the network. They are not, however, controlled by a user; instead, they are deployed to the network and run according to a set of instructions. User accounts can then engage with a smart contract by sending transactions that instruct the smart contract to perform a function. Smart contracts, like conventional contracts, can set rules and have them enforced automatically through programming. Smart contracts can't be deleted by default, and their interactions are permanent.

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Smart contracts decrease the possibility of third-party manipulation by eliminating the requirement for brokers or other intermediaries to ratify the agreement. Furthermore, the lack of an intermediary in smart contracts saves money. Because smart contracts can't send HTTP queries, they can't acquire information about "real-world" events. This is on purpose. Using external data could jeopardize consensus, which is critical for security and decentralization. The maximum contract size is another smart contract limitation. A smart contract can only be 24KB long before it runs out of gas. The Diamond Pattern can be used to get around this.

Gas

The charge, or pricing value, necessary to complete a transaction or execute a contract on the Ethereum blockchain network is referred to as gas. The gas is used to allocate resources of the Ethereum virtual machine (EVM) so that decentralized applications such as smart contracts can self-execute in a secure but decentralized manner. It is priced in small fractions of the cryptocurrency ether (ETH), commonly referred to as gwei and sometimes also called nanoeth.

Gas Limit

The usual Ethereum Gas cost limit is 21,000 units. The maximum amount of Ether Gas a user can consume to perform a transaction is referred to as the Ether Gas limit. Smart contract transactions are more sophisticated, needing more computational resources to complete. As a result, these transactions need more Gas than basic transactions such as transmitting payments.

It's fine to set a Gas limit that is too high; the EVM will refund what isn't consumed. Setting a Gas limit too low, on the other hand, could result in a user losing some ETH and their transaction being rejected.

Truffle Framework

Truffle is a platform for developing, testing, and deploying applications on the Ethereum network. Truffle, Ganache, and Drizzle are the three main development frameworks for Ethereum smart contract and decentralized application (dApp) development under the Truffle Framework.

Ganache

Ganache is a personal blockchain that allows developers to create smart contracts, dApps, and test software that is available as a desktop application and command-line tool for Windows, Mac, and Linux.

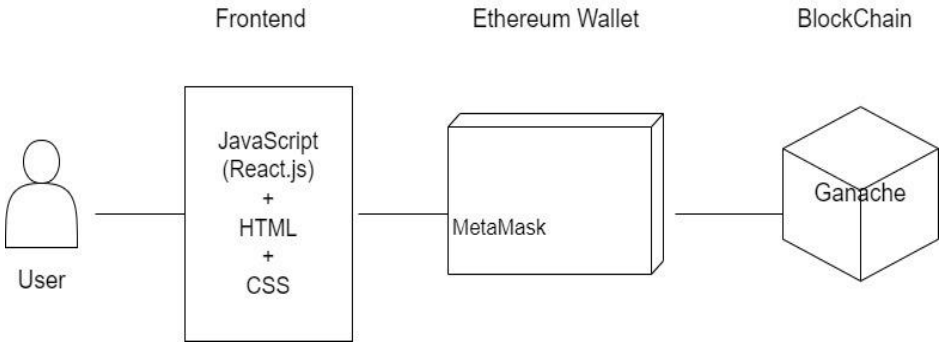

Figure 2: Overview of System Architecture

Roles

The proposed system based on blockchain has 6 roles.

Owner

Owner is the one who manages the organizations by adding different stakeholders like raw material supplier, manufacturer, distributor, retailor and customer. Also, he's responsible for adding the product or medicine. He can also track the product using QR code. Owner activities are as shown below in fig 3.

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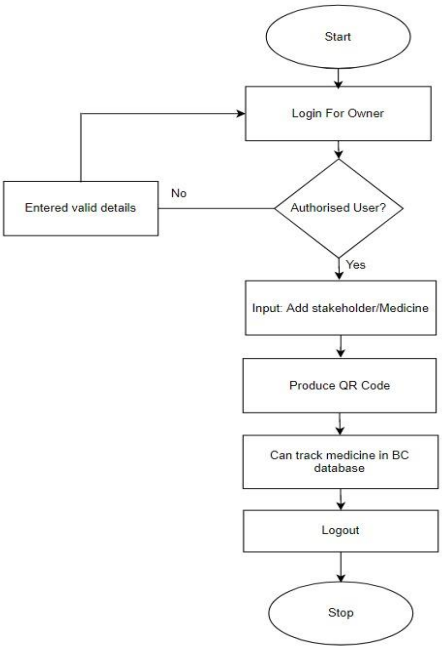

Figure 3: Activities to be carried out by the owner

Raw Material Supplier

Raw material suppliers are the one who supplies the product or service. Raw material suppliers are responsible for supplying the medicine's raw materials. They can also track the product using QR code. Raw material suppliers' activities are as shown below in fig 4.

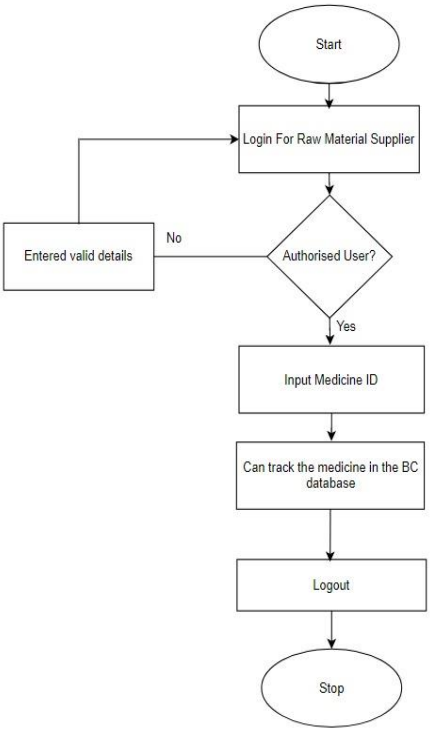

Figure 4: Activities to be carried out by the raw material supplier

Manufacturer

Manufacturers are those who create goods and services. Companies that manufacture raw materials as well as companies that generate final goods fall under this category. Manufacturers of finished goods assemble their products using raw materials and sub-assemblies made by other manufacturers. Manufacturers provide the goods and services that the rest of the supply chain relies on. Figure 5 depicts the activities of the manufacturer.

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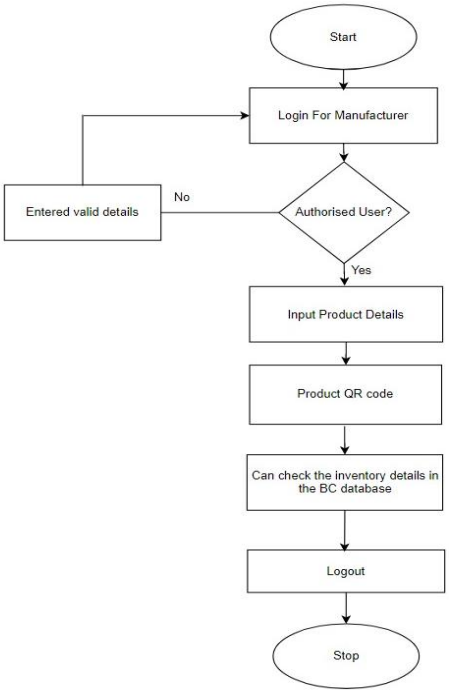

Figure 5: Activities to be carried out by the manufacturer while packing a product

Primary role of each stakeholder is to receive the product, mark the product received and send it to the next level in the supply chain as applicable until it is sold to the customer. Raw Material Supplier supplies the raw materials required to manufacture the drug to the Manufacturer. Manufacturer starts producing the drug and makes it ready for distribution in the market.

Distributor

Distributors are businesses that buy inventory in bulk from manufacturers and deliver it to clients in a bundle of related product lines. Wholesalers, distributors and suppliers are different terms for the same thing. They usually sell to other businesses and in larger quantities than an individual consumer would generally purchase. As demonstrated in figure 6, distributors protect producers from variations in product demand by holding inventory purchased from producers and performing much of the sales work to identify and fulfil customer needs.

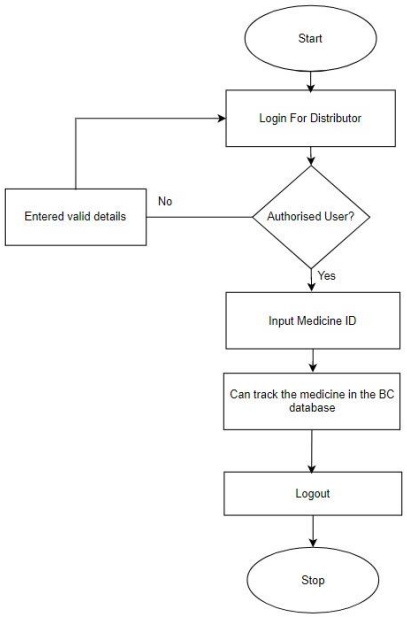

Figure 6: Activities to be carried out by the distributor while marking a product

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Retailer

Retailers are the one who delivers the product or service to the customer. Retailers are responsible for retailing the product or medicine. They can also track the product using QR code. Retailer's activities are as shown below in fig 7.

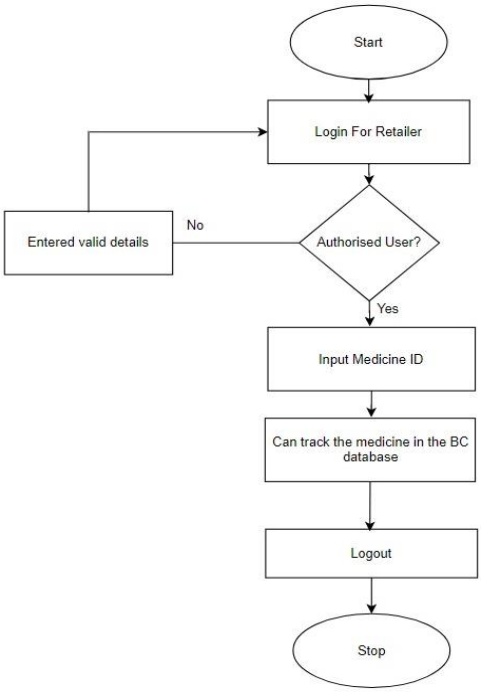

Figure 7: Activities to be carried out by the retailer

Customer

Individuals or organizations who buy and use a product or service are known as customers (or consumers). A client could be a company that buys a product to include it into a different product that they then sell to their customers (ultimate customers). Customers rely on producers, distributors, and retailers to fulfil their product and service requirements.

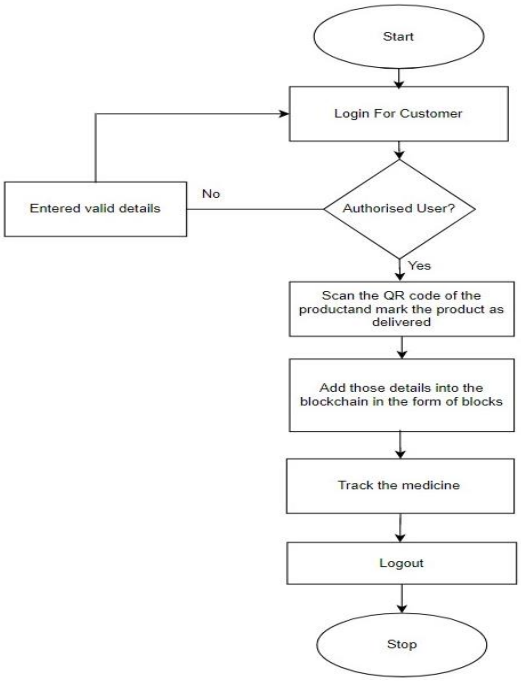

Figure 8: Activities to be carried out by the customer

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When a customer logs in for the first time, he will be requested to provide information such as his name, address, phone number, and government-issued identification. He will be able to log in straight after the initial registration. When a customer receives medications from a supplier, he must scan or upload the QR code on the pharmaceutical supply. He will be able to tell whether the pills he received are genuine or not. Figure 8 depicts a customer's activities.

III. IMPLEMENTATION

In this chapter, we go through the specifics of our system's architecture, including a detailed explanation of its purpose and user interface. Our objective is to employ Blockchain features to give raw material suppliers, manufacturers, distributors, retailers, and customers with a more comprehensive, convenient, and low-cost product anti-counterfeiting solution.

PROGRAMMING LANGUAGE AND SYSTEM STRUCTURE

The suggested system makes use of Ethereum as the back end and Solidity, Ethereum's proprietary programming language, as the high-level programming language for creating smart contracts. Solidity enables inheritance, library import, and other features. Solidity is intended for use with the Ethereum Virtual Machine (EVM). Solidity, unlike Bitcoin's scripts, supports loops and is Turing complete.

The public smart contract on the system is built on Ethereum's Blockchain. In this work, we utilize Ganache to establish a private chain and push the smart contract onto it for testing purposes, such that the Private chain replicates the condition on the Public chain.

A web page is the user interface that the user sees. The server side of the web page is built with node.js's http-server package, while web3.js serves as the interface between the smart contract and the user interface. After configuring the server, the Private Chain and Address information may be linked. Figure 9 depicts the entire system connection.

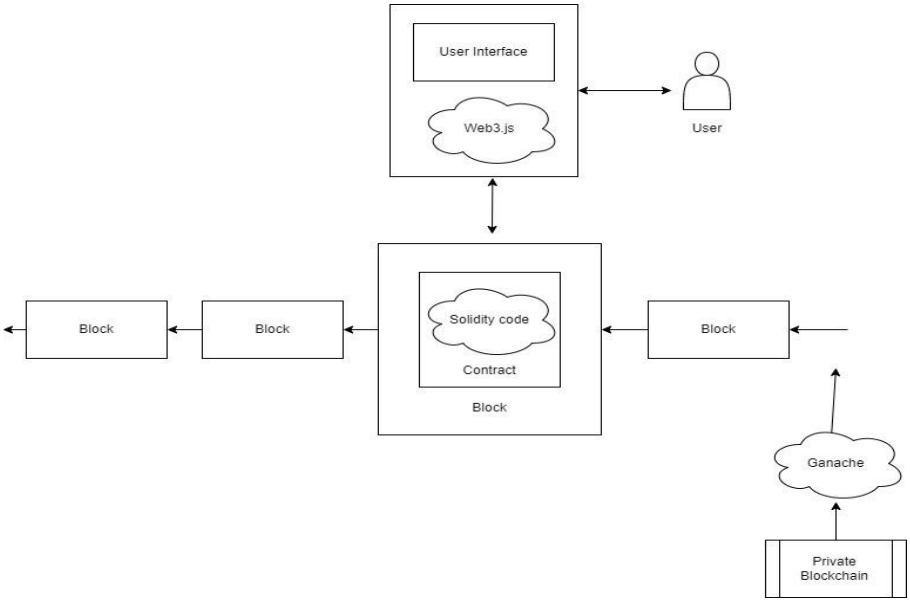

Figure 9: System structure overview

System Operation

- Login Process: To connect to the system, the user needs to select the account from metamask, which is basically a wallet that stores number of accounts. Metamask is basically used to interact with Ethereum Blockchain system. The user's accounts are connected to accounts in Ganache, as long as Ganache is initiated, the user can choose the account which is linked to the account in Ganache. The user is required to import the account by typing the private key, which can be obtained from Ganache blockchain emulator. Then, the user can modify the basic details of the account imported and save it. The process is depicted in the Figure 10.

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- Scope of Information of Contract: With the goal of information disclosure, the information about raw material supplier, manufacturer, distributor, retailer and all details associated with the particular product is provided to the customer as well as all stakeholders associated in the supply chain. Anyone can view the details by going to track page and enter that particular product ID. The data storage format in the smart contract is displayed in the table shown in Figure 11.
- Adding New Stakeholders and medicines: In our system, the owner can control all stakeholder's information, including adding new stakeholders and medicine details. The program in the smart contract will first check if the function is called by the owner. If true, then program will construct that particular stakeholder or medicine Struct accordingly and stores all details about the stakeholder or medicine accordingly.
- Changing the password: The owner sets default password to each stakeholder and later they can change it as they need.
- Controlling Supply chain: In our system, the stakeholders can login and just enter the details of the medicine by manually entering or by scanning the QR code. Then the smart contact checks whether the product is currently with the stakeholder just behind the requester in the chain and if correct, the ownership is transferred and marked as manufactured, retailed, distributed or sold based on the situation. If not correct, error notification will be displayed.
- Marking the product as sold: Once the customer does login and purchases the products, the product status is marked as sold and the chain for that particular product will end there.

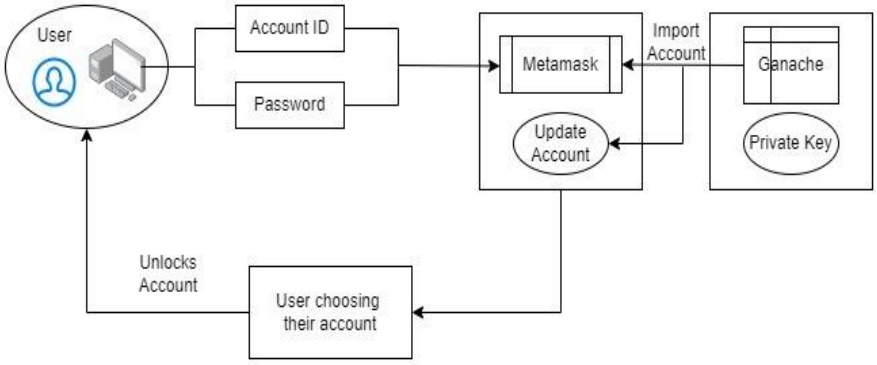

Figure 10: Login Process

Name of the Struct	Data type	Attributes
Medicine	int	ID
	string	name
	string	desc
	int	price
	string	mfd
	string	dosage
	string	exp
	enum	stage
	string	customer
Raw material supplier	int	ID
	string	name
	string	password
	string	place
	address	address
Manufacturer	int	ID
	string	name
	string	password
	string	place
	address	Address
Distributor	int	ID
	string	Name

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	string	Password
	string	Place
	address	Address
Retailer	int	ID
	string	Name
	string	Password
	string	Place
	address	Address
Customer	int	ID
	string	Name
	string	Password
	string	Place
	address	Address

Figure 11: Data Storage Format

IV. CONCLUSION

In this project, we proposed and implemented a further use case of blockchain technology in healthcare. We pointed out the issues in current pharmaceutical supply chain management, and explained how blockchain can be used to add traceability and visibility to drugs supply and overcome the issue of counterfeiting and implemented the solution. How the identity mechanism of blockchain works and how is it helpful to share medical data by keeping the products supply details secure is explained and implemented. In the last we explained the working of the suggested system with an example that shows how the system will be easily used by different participants.

This defines a blockchain method to enhance the current supply chain, management model and also in supply chain commodities blockchain technology helps to connect the people from various locations. So, we have implemented the distributed ledger in the supply chain. Distributed ledger in the above drug supply chain contains all the transactions and transportation details. It is very confident that no one can attack. Moreover, we implemented a QR code system which helps to track the product easily and reduces manual work. Advantage of this is anyone from manufacturer to consumer side to get the details about the product that is integrity of product from manufacturing to usage of it.

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