VIT®

Vellore Institute of Technology

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School of Computer Science and Engineering

Supply Chain Management using Blockchain and IoT

A project submitted

in partial fulfillment of the requirements for the degree of Bachelor of Technology in Computer Science and Engineering

Submitted By:

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Course

Instructor

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Assistant Professor

Undertaking

This is to declare that the project entitled **“Pharmaceutical Supply Chain Management using Blockchain and IoT"** is an original work done by undersigned, in partial fulfillment of the requirements for the degree “Bachelor of Technology in Computer Science and Engineering” at School of Computer Science and Engineering, Vellore Institute of Technology (VIT), Vellore.

All the analysis, design and system development have been accomplished by the undersigned. Moreover, this project has not been submitted to any other college or University.

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ABSTRACT

Supply chain management is the management of the flow of goods and services and includes all processes that transform raw materials into final products. It involves the active streamlining of a business's supply-side activities to maximize customer value and gain a competitive advantage in the marketplace.

In 2020, the global supply chain management market was valued at 15.85 billion U.S. dollars and is expected to reach almost 31 billion U.S. dollars by 2026. Today, Supply Chain Management is one of the most popular areas of research and innovation.

This Project proposes the use of IOT and Blockchain to make the Supply chain management process more efficient and secure. IOT sensors and devices can be used to collect important data related to the products and the environment and Blockchain is used to ensure its integrity and availability.

OBJECTIVE

To develop a platform that will simulate a pharmaceutical supply chain using blockchain to secure the data in a public ledger. This enables transparency and reliability of the supply chain as data can be verified by all but modified by none.

APPLICATIONS

Supply chain data is not always visible, available or trusted. Blockchain helps supply chain partners share trusted data through permissioned blockchain solutions. In times of disruption, this matters more than ever. Businesses and consumers want brands to guarantee product authenticity, while supply chain participants demand responsible sourcing and better visibility to minimize disputes.Blockchain for supply chain solutions help supply chain leaders use data to handle the disruptions of today and build resiliency for the future

NOVELTY

Our project uses a public blockchain integrated with IoT technologies. This helps prevent certain attacks such as DDoS which are common in other database implementations. Verifying the integrity of data is also better managed in blockchain technology as data modification is not possible. Thus, the customer can be worry-free from things such as mishandled or damaged goods.

Advantages

- Improved Efficiency: Because it relies on a shared network infrastructure, a supply chain using blockchain technology improves communication and collaboration for all parties. Greater traceability and transparency eliminate waste, duplicate orders and accounts payable headaches such as invoice fraud and rogue spend. Contract compliance contingencies encourage all parties to meet their agreed-upon obligations in a timely, complete and accurate fashion. Full visibility of financial information and performance improves financing options for small businesses and lowers processing times by reducing uncertainty and risk.
- More Ethical, Sustainable Sourcing: The traceability and tamper-resistance of the blockchain make it easier to verify where materials and goods come from, where they go as they travel through the supply chain and who has access to them
- Greater Savings: The gains to efficiency and reductions in stock loss and waste are significant sources of cost savings with blockchain technology. A distributed network sharing resources and transactions digitally also eliminates the need for paper-based workflows and materials. Going paperless doesn't just lower materials costs; it also eliminates ancillary costs related to storage.

INTRODUCTION

What is blockchain?

Blockchain is a distributed, immutable ledger that makes recording transactions and tracking assets in a business network much easier. An asset can be tangible (a house, car, cash, land) or intangible (intellectual property, patents, copyrights, branding). On a blockchain network, virtually anything of value can be tracked and traded, lowering risk and costs for all parties involved.

What is the significance of blockchain?

Information is the backbone of business. The faster it's received and the more accurate it is, the better. Since it provides immediate, shared, and completely transparent information stored on an immutable ledger that can only be accessed by permissioned network members, blockchain is ideal for delivering that information. Orders, payments, accounts, production, and much more can all be tracked using a blockchain network. You can see all details of a transaction end to end because members share a single view of the truth, giving you greater confidence as well as new efficiency gains and opportunities.

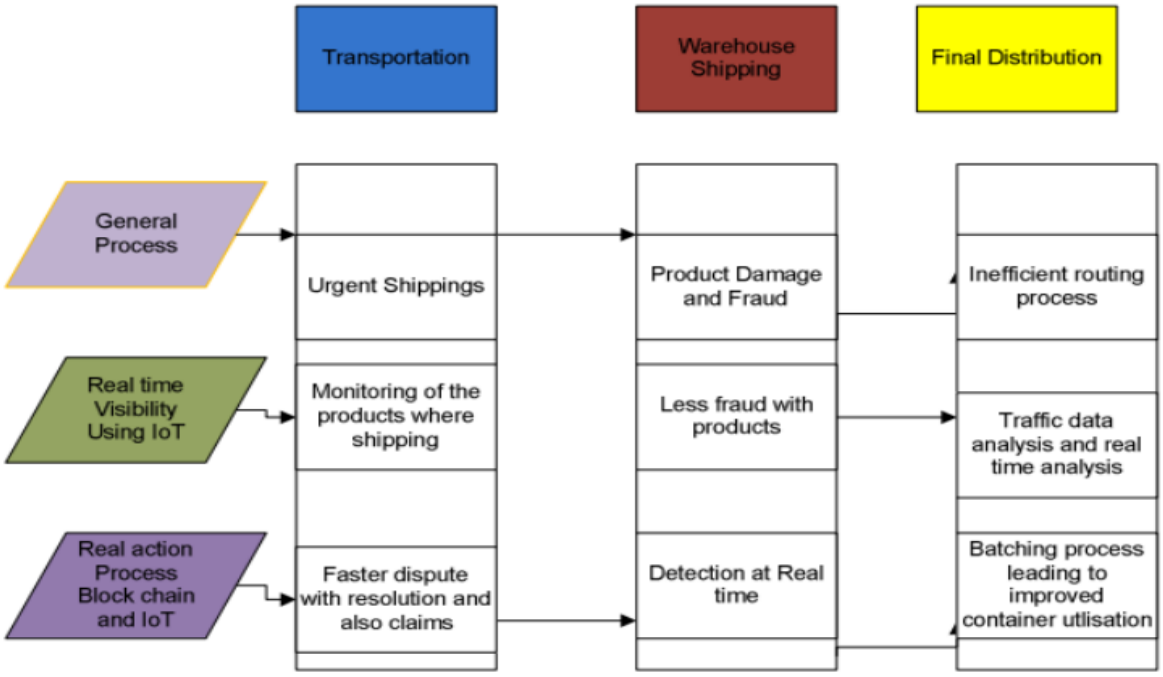
How blockchain and IoT can support a Pharmaceutical supply chain?

Supply chains nowadays are complex and distributed, involving a large number of parties. To accurately monitor assets, supply chain companies are upgrading their business operations by implementing technologies such as IoT and blockchain.
IoT sensors are used to collect data about environmental conditions, verify how long cargo stays in a specific truck or at a specific port, and whether it's being tampered with or affected by any means that violates the handling instructions. This data can be used to settle invoice disputes and provide proof for insurance claims. It also benefits businesses by assisting them in improving the efficiency of their supply chain operations.

A blockchain-based supply chain management system is based on a shared distributed ledger that keeps a permanent record of all data related to shipment status, truck status, storage conditions, and more.

Using blockchain and IoT technologies, both the company and the consumer can track the entire product life cycle throughout the supply chain. Blockchain is a precise data record that saves the history of all communications between IoT devices. It gives users instant access to all product information, such as the date when a certain medication was manufactured, transported and sold to the consumer.

Even in cross-border trades, blockchain and IoT together ensure safe cargo shipping. The system works in the same way as an online agreement between all parties involved in a transaction. The contract's terms and conditions can be said to be written in computer codes, allowing for seamless financial transactions between unknown parties.



Literature Survey

Some Related research work that has been already done are:

1. **Supply Chain Management based on Blockchain: A Systematic Mapping Study -**
   Tribis, Youness & El Bouchti, Abdelali & Bouayad, Houssine. (2018)
   The work aimed to explore and analyze the state-of-the-art on blockchain technology (applications for Supply Chain Management. The study synthesized existing evidence, and identified gaps, available in the literature. The survey used a systematic mapping study (SMS) method to examine 40 extracted primary studies from scientific databases.

2. **Blockchain Technology for Supply Chain Management**
   Dursun, Taner & Birinci, Fatih & Alptekin, Büşra & Sertkaya, Isa & Hasekioglu, Orkun & Tunaboylu, Bahadir & Zaim, Selim. (2022)
   This paper aimed to overview the employment of blockchain technology in the field of the supply chain. Blockchain can provide a permanent, shareable, auditable record of products through their supply chain, which improves product traceability, authenticity, and legality in a more cost-effective way. In this research, the potential improvement expectations via blockchain technology for the case of
   agribusiness were discussed. The proposed case for automotive manufacturing-micro factory with blockchain technology was also introduced.

3. **Applications of Blockchain to Improve Supply Chain Traceability-Ju Myung Song, Jongwook Sung, Taeho Park, (2019)**
   One of the most important functions of the SCM is to improve the transparency, traceability and auditability of materials flow throughout the supply chain from suppliers, manufacturing facilities, warehouses/distribution centres, to customers. This research especially focused on the impact of blockchain on supply chain traceability through the current industry applications, and its future direction.

4. **Security of Blockchain-Based Supply Chain Management Systems: Challenges and Opportunities-**
   Al-Farsi, Sana & Rathore, Muhammad Mazhar & Bakiras, Spiros. (2021)
   The goal of this study was to investigate practical threats and vulnerabilities in the design of BlockChain- Supply Chain Management systems. As a starting point, it established key requirements for the reliability and security of supply chain management systems, i.e., transparency, privacy and traceability, and then discern a threat model that includes two distinctive but practical threats including computational (i.e., the ones that threaten the functionality of the application) and communication (i.e., the ones that threaten information exchange among interconnected services of the application).
   For investigation, the paper followed a unique approach based on the hypothesis that reliability is a prerequisite of security and identify the threats considering (i) design of smart contracts and associated supply chain management applications,
   (ii) underlying blockchain execution environment and
   (iii) trust between all interconnected supply management services. Moreover, the research considered both academic and industry solutions to identify the threats. It identified several challenges that hinder the establishment of reliability and security of the BC-SCM systems. Importantly, It also highlighted research gaps that can help to establish desired security of the BC-SCM.
   Finally, this work established the foundation for future investigation towards practical security of the BC-SCM system.

5. **Blockchain technology for security issues and challenges in IoT-Nallapaneni Manoj Kumar, Pradeep Kumar Mallick, (2018)**
   This paper elaborated the possible security and privacy issues considering the component interaction in IoT and studies how the distributed ledger based blockchain (DL-BC) technology contributes to it. Applications of BC with respect to focused sectors and categories were clearly studied here. Various challenges specific to IoT and IoT with BC were also discussed to

understand blockchain technology contribution.

6. **BLOCKCHAIN and IoT for Enhancing Supply Chain Security – A review**
   Basha, Mir Mohammed Junaid & Ap, Nikitha & Fathima K, Aiman & Galagali, Deepthi & Gupta, Dr & Subramanya, K.N.. (2020).
   This paper looked at various challenges a traditional supply chain faces such as Inventory theft, Information theft, Smuggling and Piracy, Trusting data to third party vendors. So, there was a high sense of need for security and monitoring for the data as well as the products.
   This paper also discussed the steps involved in implementation of Blockchain. It summarized how Blockchain, which when combined with the IoT platform, will provide a real time and a secure supply chain. By doing so, the productivity, efficiency, and profitability of the supply chain can be improved.

7. **Blockchain for IoT-Based Digital Supply Chain: A Survey-**
   Haibo Zhang, Kouichi Sakurai, 2020
   This exploratory investigation aimed to discuss the current network environment of digital supply chain systems and security issues, especially from the Internet world, of digital supply chain management systems with applying some advanced information technologies, such as Internet of Things and blockchain, for improving various system performance and properties.
   The paper introduced the general histories and backgrounds, in terms of information science, of the supply chain and relevant technologies which have been applied or are potential to be applied on the supply chain with the purpose of lowering cost, facilitating its security and convenience. It provided a comprehensive review of current relative research work and industrial cases from several famous companies. It also illustrated the IoT enablement and security issues of the current digital supply chain system, and existing blockchain's role in this kind of digital system.
   Finally, this paper concluded several potential or existing security issues and challenges which supply chain management is facing.

8. **Blockchain Technology in Supply Chain Management: A Review - Bushra Mukri 2018**
   This paper gave an overview of blockchain technology and its potential in making supply chain management more efficient.

9. **Investigation of blockchain applicability to Internet of Things within supply chains Älvebrink Johan, Jansson, Maria (2018)**
   This paper looked into up-to-date research of blockchain and IoT with the purpose to study blockchain as a potential solution to secure IoT data management within supply chains.
   Both blockchain and IoT are relatively new research areas with little existing research, which support the use of a qualitative inductive method. Semi-structured interviews had been conducted with people working within the fields of blockchain, IoT and supply chain

10. **Blockchain and IoT for Delivery Assurance on Supply Chain (BIDAS)-**
    M. Demir, O. Turetken and A. Ferwom, (2019)
    This paper focused on delivery assurance in the supply chain industry, and proposed a novel blockchain-based transparent delivery framework for creating solutions that record and share data on the interaction of business participants. This framework helps create solutions that include handover and monitoring aspects of the delivery businesses and adds several benefits that come with the blockchain technology.

PROPOSED METHODOLOGY

Proposed Framework:

- There are very few projects and other works that use IOT and Blockchain in supply chain especially in the Pharmaceutical supply chain.

- First we will get our data for the pharmaceutical supply chain. Data will include location, temperature, quantity, quality check, etc. for medicine.

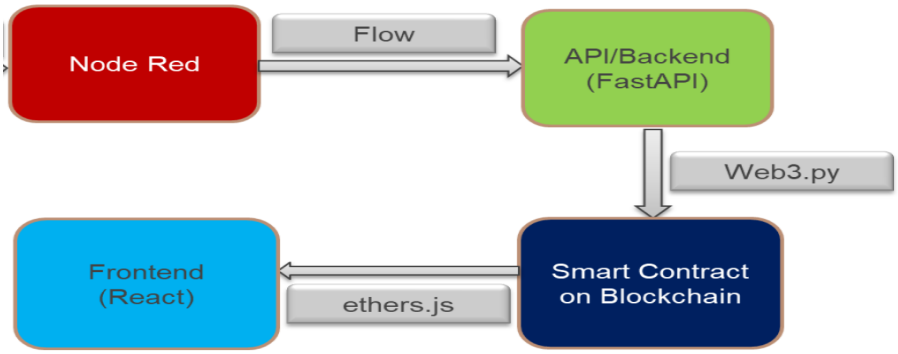
- Then we send this data to **NODE-RED**. Now, from node red we will take decisions based on received data like sending email if temperature goes below critical point or package reached destination.

- We can also implement an auto pay system such that if a package is delivered we will send ETH from one account to another.

- For interaction with blockchain we will use **FASTAPI** as backend and **WEB3.PY** library.

- Also, we are building Frontend using **REACTJS** and **Ethers.js** to show data and current status of the product. So, users can track their product status using our app and they can get the information related to the product from the app.

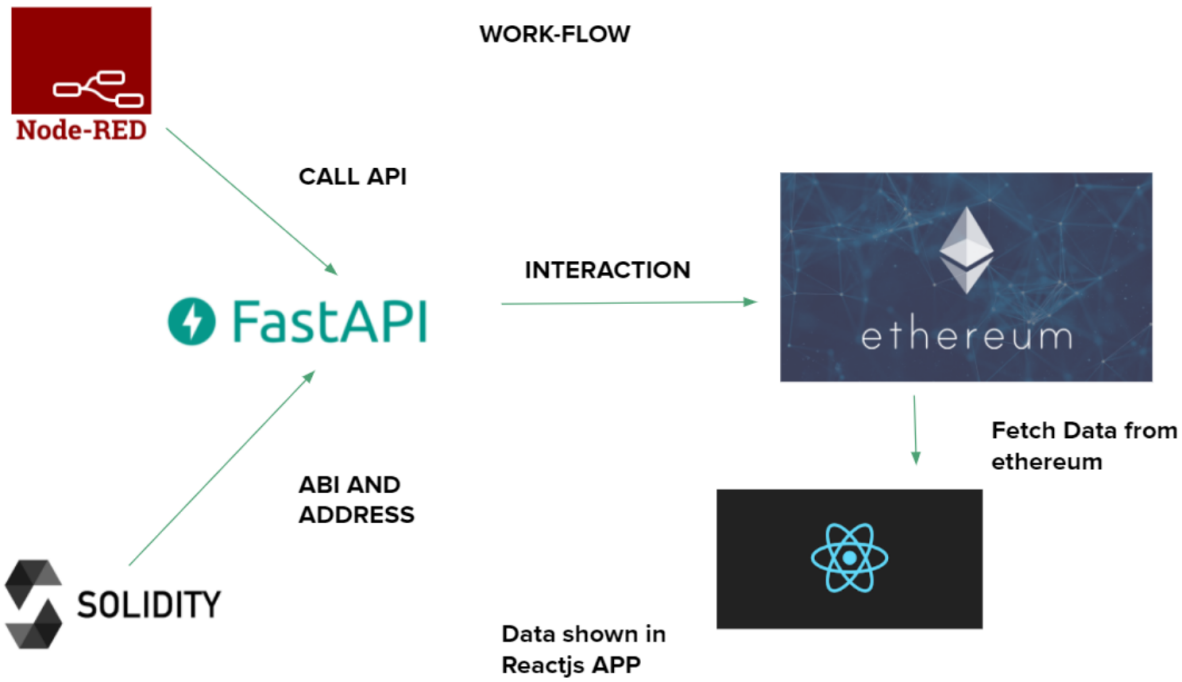
Block Diagram:



Pseudocode/Algorithm:

1. Pass the data through platform like node-red
3. filter the data and pass that data to api
4. API connects node red to smart contract
5. We can call smart contract functions through that api such as add data to blockchain
6. We can also send data apart from sensors like we can send data via manually or with the help of softwares
7. Now users and staffs can see this data via frontend

Architecture/Design:

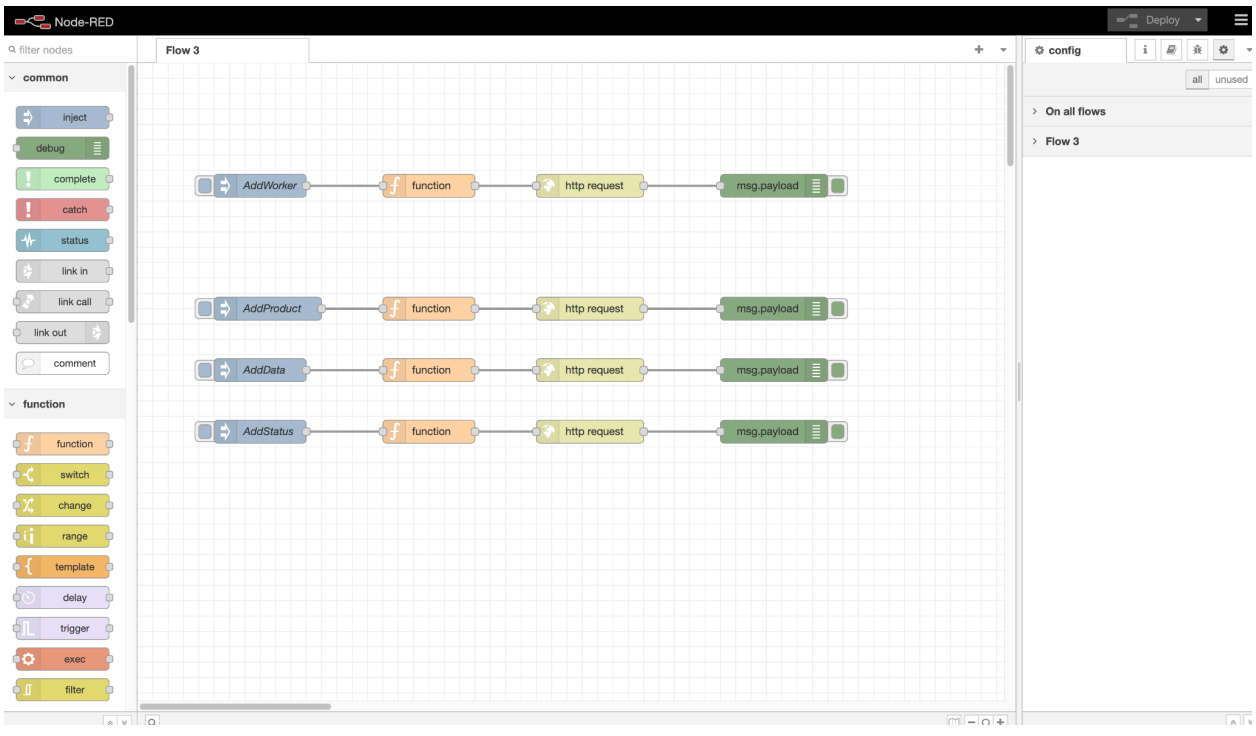


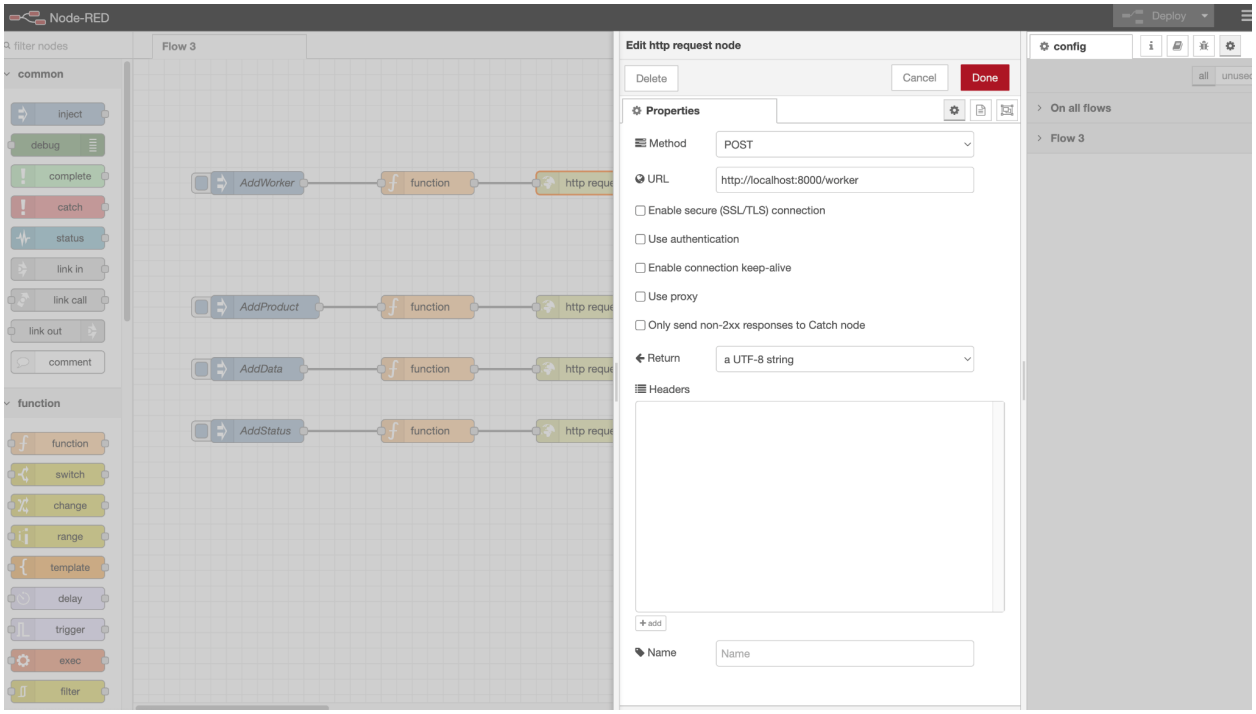
Implementation

```python
import json
from fastapi import FastAPI,Request
from fastapi.responses import JSONResponse
from fastapi.middleware.cors import CORSMiddleware
import uvicorn
#from contract import *
from router import worker
from router import product

app = FastAPI()
app.include_router(worker.router)
app.include_router(product.router)



@app.get('/')
def index():
  return {'message': 'Hello world!'}


origins=['http://localhost:3000/']
app.add_middleware(CORSMiddleware,allow_origins=origins,allow_credentials=True,allow_methods=["*"],allow_headers=["*"])
```

```python
from web3 import Web3
from web3.middleware import geth_poa_middleware
from eth_account import Account
import json
from dotenv import load_dotenv
import os
load_dotenv()

w3 = Web3(Web3.HTTPProvider(
    "https://eth-ropsten.alchemyapi.io/v2/-4TAg-d6XKuHICQaF7yZfF2BfQ3BpR5t"))
w3.middleware_onion.inject(geth_poa_middleware, layer=0)

abi = json.loads("""[…


key = "e50f77a48f47d321ffd657ed37c22353fe97de2ce15bdec122cd7a6e86b8181b"
account = w3.toChecksumAddress('0x32b1Ef87a3002e7417BB7a86428700BF0b74c50c')  # account

address = w3.toChecksumAddress('0x8bCAbDF3841F8035a4fEb2f62FFd70f670869C78') # contrat address
deployed_contract = w3.eth.contract(address=address, abi=abi)


def setWorker(name):
  transaction = deployed_contract.functions.setWorker(name).buildTransaction({'from': account})
  transaction.update({'nonce': w3.eth.get_transaction_count(account)})
  signed_tx = w3.eth.account.sign_transaction(transaction, key)
  txn_hash = w3.eth.send_raw_transaction(signed_tx.rawTransaction)
  txn_receipt = w3.eth.wait_for_transaction_receipt(txn_hash)
  print(txn_receipt)
  return "worker added"


def AddProduct(name, price, description, reqtemp,manufacturing):
  transaction = deployed_contract.functions.AddProduct(name, price, description, reqtemp,manufacturing).buildTransaction({'from':
  account})
  transaction.update({'nonce': w3.eth.get_transaction_count(account)})
  signed_tx = w3.eth.account.sign_transaction(transaction, key)
  txn_hash = w3.eth.send_raw_transaction(signed_tx.rawTransaction)
  txn_receipt = w3.eth.wait_for_transaction_receipt(txn_hash)
  print(txn_receipt)
  return "product added"
```

```python
def AddStatus(location, temp,humidity,heatindex, wid, pid,total_quantity,flag):
  transaction = deployed_contract.functions.AddStatus(location, temp, humidity, heatindex, wid, pid, total_quantity,flag).
  buildTransaction({'from': account})
  transaction.update({'nonce': w3.eth.get_transaction_count(account)})
  signed_tx = w3.eth.account.sign_transaction(transaction, key)
  txn_hash = w3.eth.send_raw_transaction(signed_tx.rawTransaction)
  txn_receipt = w3.eth.wait_for_transaction_receipt(txn_hash)
  print(txn_receipt)
  return "status added"

def AddData( temp,humidity,heatindex, pid):
  transaction = deployed_contract.functions.AddData(temp, humidity, heatindex, pid).buildTransaction({'from': account})
  transaction.update({'nonce': w3.eth.get_transaction_count(account)})
  signed_tx = w3.eth.account.sign_transaction(transaction, key)
  txn_hash = w3.eth.send_raw_transaction(signed_tx.rawTransaction)
  txn_receipt = w3.eth.wait_for_transaction_receipt(txn_hash)
  print(txn_receipt)
  return "sensor data added"

def  getProductsList():
    return deployed_contract.functions.getProductsList().call()

def getWorkersList():
   return deployed_contract.functions.getWorkerssList().call()

def getProductStatus(pid):
   return deployed_contract.functions.getProductStatus(pid).call()

def getProductData(pid):
    return deployed_contract.functions.getProductData(pid).call()

def getProducts():
    return deployed_contract.functions.getProducts().call()
```

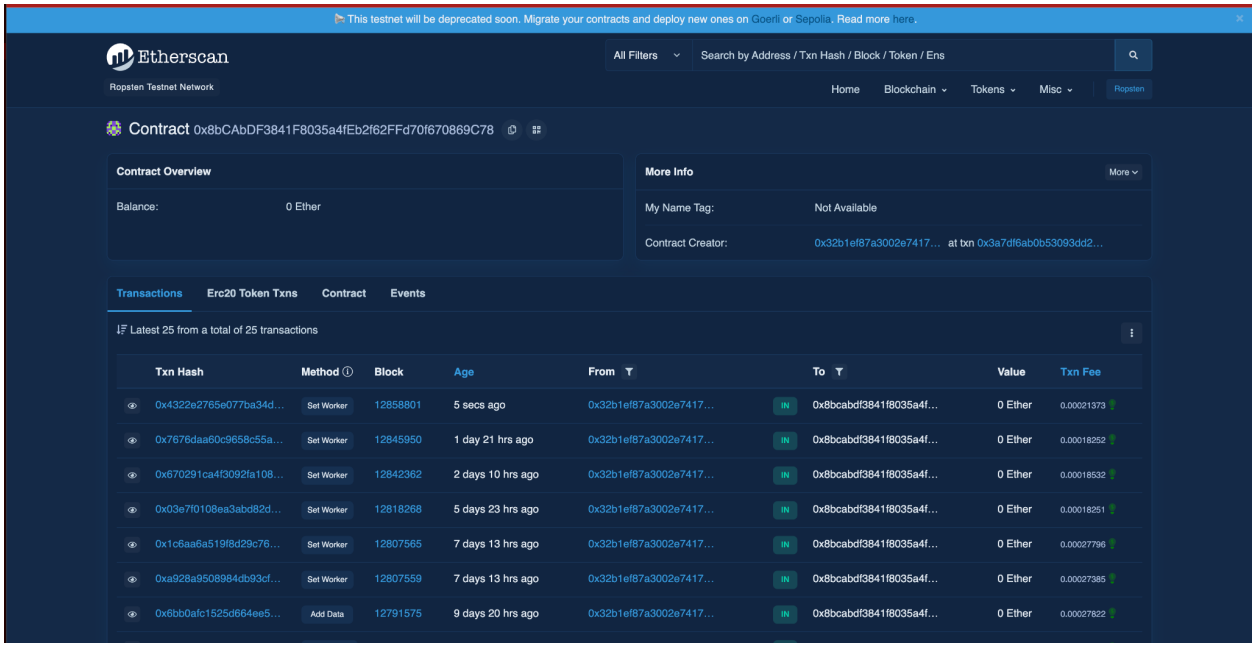


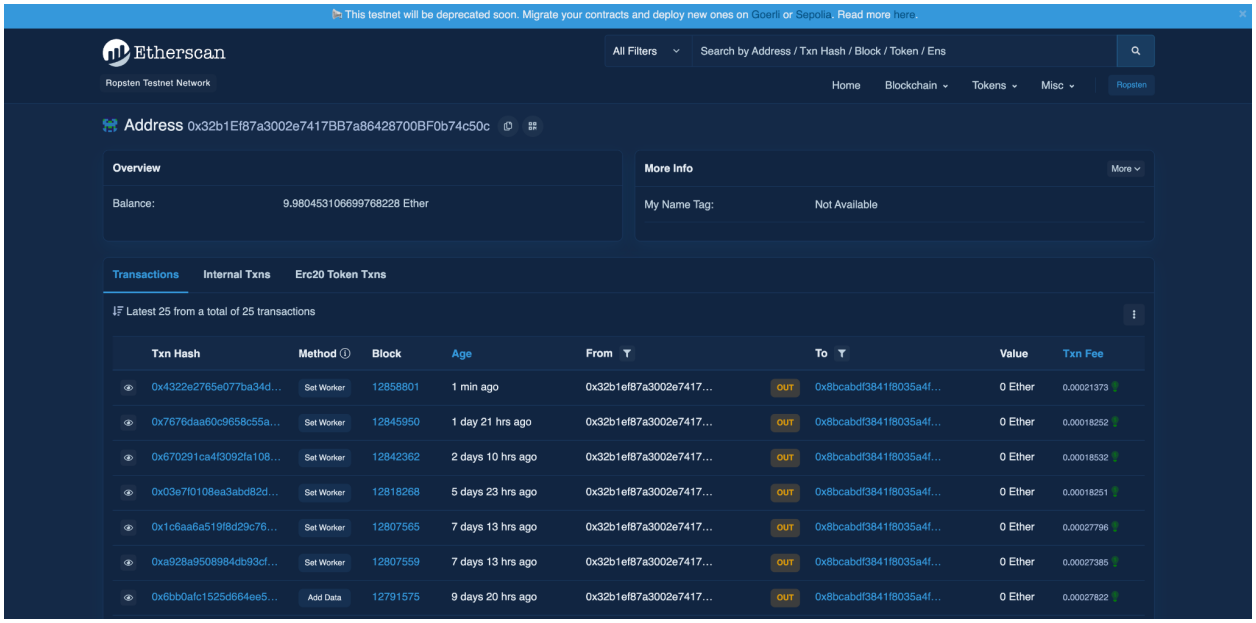

Node-RED
Deploy
filter nodes
Flow 3
common
inject
debug
complete
catch
status
link in
link call
link out
comment
function
function
switch
change
range
template
delay
trigger
exec
filter
AddWorker
function
AddProduct
function
AddData
function
AddStatus
function
Edit http request node
Delete
Cancel
Done
Properties
Method
POST
URL
http://localhost:8000/worker
Enable secure (SSL/TLS) connection
Use authentication
Enable connection keep-alive
Use proxy
Only send non-2xx responses to Catch node
Return
a UTF-8 string
Headers
add
Name
Name
config
all
unused
On all flows
Flow 3

```
pragma solidity >= 0.8.0;

contract Supplychain{

    address owner;

   constructor() public {
      owner = msg.sender;
   }

   fallback() external payable {
    }

    receive() external payable {
    }

uint256 product_id=0;
uint256 worker_id=0;

struct Product{
    uint256 id;
    string name;
    string price;
    string description;
    string reqtemp;
    string manufacturing;
    uint256 timestamp;
}

struct Status{
    string location;
    uint256 timestamp;
    string temp;
    string humidity;
    string heatindex;
    uint256 w_id;
    uint256 p_id;
    uint256 total_quantity;
    bool flag;
}
```

Link: [Link to code]

Testing


This testnet will be deprecated soon. Migrate your contracts and deploy new ones on Goerli or Sepolia. Read more here.
Etherscan
Ropsten Testnet Network
All Filters
Search by Address / Txn Hash / Block / Token / Ens
Home
Blockchain
Tokens
Misc
Ropsten
Contract 0x8bCAbDF3841F8035a4fEb2f62FFd70f670869C78
Contract Overview
Balance:
0 Ether
More Info
More
My Name Tag:
Not Available
Contract Creator:
0x32b1ef87a3002e7417... at txn 0x3a7df6ab0b53093dd2...
Transactions
Erc20 Token Txns
Contract
Events
Latest 25 from a total of 25 transactions
Txn Hash
Method
Block
Age
From
To
Value
Txn Fee
0x4322e2765e077ba34d...
Set Worker
12858801
5 secs ago
0x32b1ef87a3002e7417...
IN
0x8bcabdf3841f8035a4f...
0 Ether
0.00021373
0x7676daa60c9658c55a...
Set Worker
12845950
1 day 21 hrs ago
0x32b1ef87a3002e7417...
IN
0x8bcabdf3841f8035a4f...
0 Ether
0.00018252
0x670291ca4f3092fa108...
Set Worker
12842362
2 days 10 hrs ago
0x32b1ef87a3002e7417...
IN
0x8bcabdf3841f8035a4f...
0 Ether
0.00018532
0x03e7f0108ea3abd82d...
Set Worker
12818268
5 days 23 hrs ago
0x32b1ef87a3002e7417...
IN
0x8bcabdf3841f8035a4f...
0 Ether
0.00018251
0x1c6aa6a519f8d29c76...
Set Worker
12807565
7 days 13 hrs ago
0x32b1ef87a3002e7417...
IN
0x8bcabdf3841f8035a4f...
0 Ether
0.00027796
0xa928a9508984db93cf...
Set Worker
12807559
7 days 13 hrs ago
0x32b1ef87a3002e7417...
IN
0x8bcabdf3841f8035a4f...
0 Ether
0.00027385
0x6bb0afc1525d664ee5...
Add Data
12791575
9 days 20 hrs ago
0x32b1ef87a3002e7417...
IN
0x8bcabdf3841f8035a4f...
0 Ether
0.00027822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Etherscan
Ropsten Testnet Network
All Filters
Search by Address / Txn Hash / Block / Token / Ens
Home
Blockchain
Tokens
Misc
Ropsten
Address 0x32b1Ef87a3002e7417BB7a86428700BF0b74c50c
Overview
Balance:
9.980453106699768228 Ether
More Info
More
My Name Tag:
Not Available
Transactions
Internal Txns
Erc20 Token Txns
Latest 25 from a total of 25 transactions
Txn Hash
Method
Block
Age
From
To
Value
Txn Fee
0x4322e2765e077ba34d...
Set Worker
12858801
1 min ago
0x32b1ef87a3002e7417...
OUT
0x8bcabdf3841f8035a4f...
0 Ether
0.00021373
0x7676daa60c9658c55a...
Set Worker
12845950
1 day 21 hrs ago
0x32b1ef87a3002e7417...
OUT
0x8bcabdf3841f8035a4f...
0 Ether
0.00018252
0x670291ca4f3092fa108...
Set Worker
12842362
2 days 10 hrs ago
0x32b1ef87a3002e7417...
OUT
0x8bcabdf3841f8035a4f...
0 Ether
0.00018532
0x03e7f0108ea3abd82d...
Set Worker
12818268
5 days 23 hrs ago
0x32b1ef87a3002e7417...
OUT
0x8bcabdf3841f8035a4f...
0 Ether
0.00018251
0x1c6aa6a519f8d29c76...
Set Worker
12807565
7 days 13 hrs ago
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OUT
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Set Worker
12807559
7 days 13 hrs ago
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OUT
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0 Ether
0.00027385
0x6bb0afc1525d664ee5...
Add Data
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9 days 20 hrs ago
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OUT
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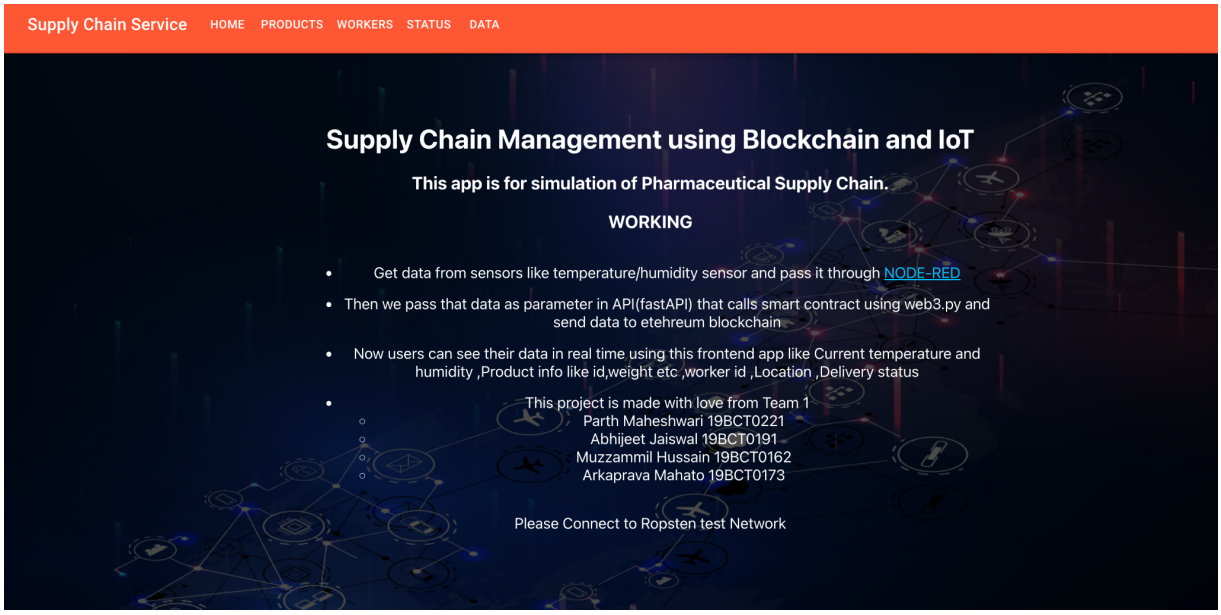
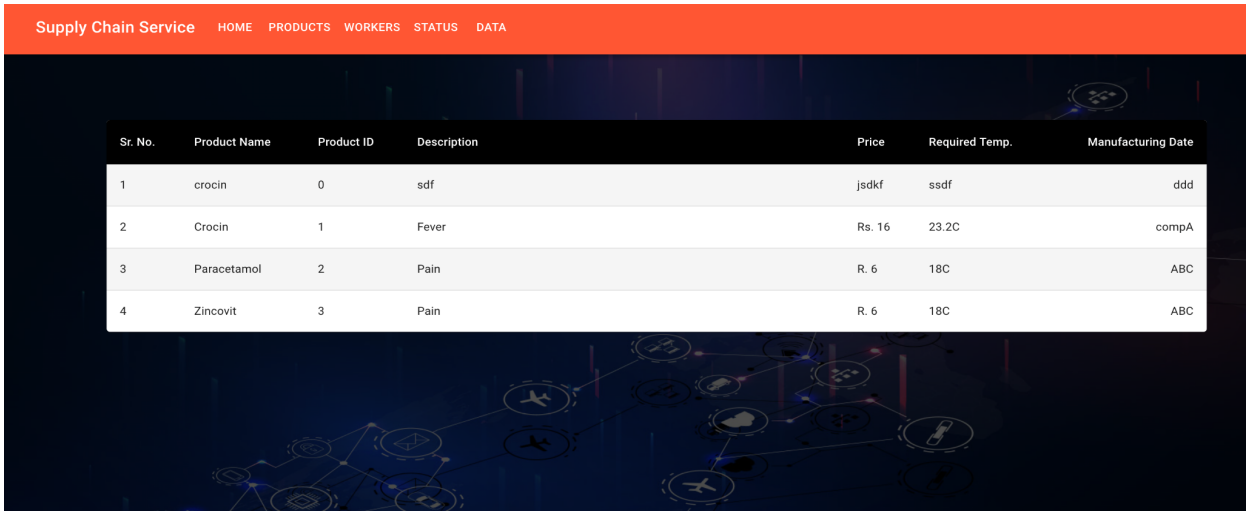
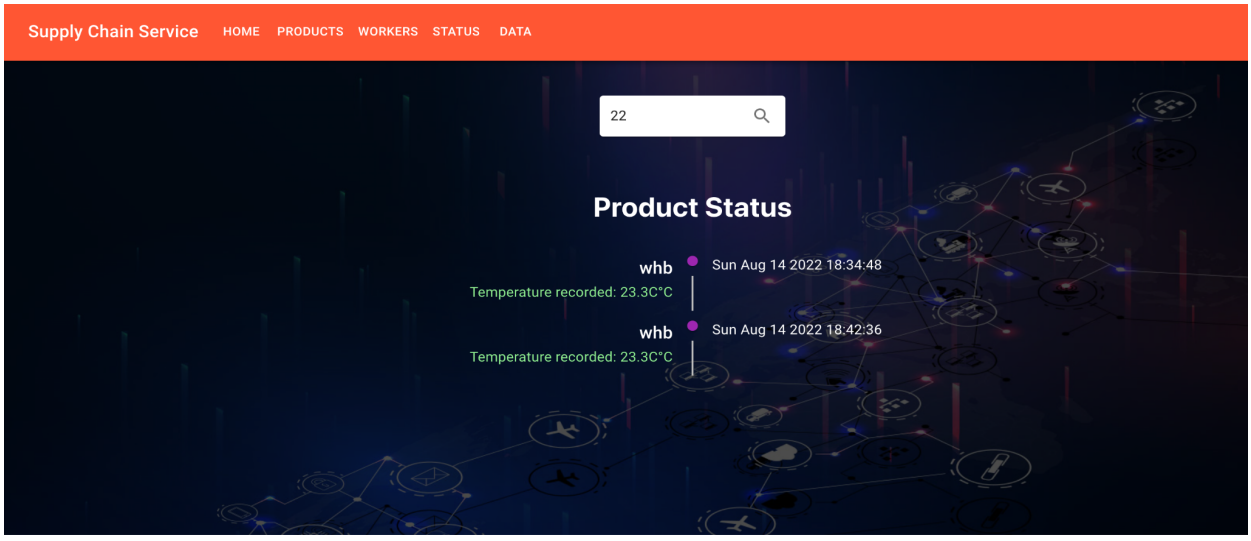
0 Ether
0.00027822


Supply Chain Service
HOME PRODUCTS WORKERS STATUS DATA
Supply Chain Management using Blockchain and IoT
This app is for simulation of Pharmaceutical Supply Chain.
WORKING
Get data from sensors like temperature/humidity sensor and pass it through NODE-RED
Then we pass that data as parameter in API(fastAPI) that calls smart contract using web3.py and send data to etehreum blockchain
Now users can see their data in real time using this frontend app like Current temperature and humidity ,Product info like id,weight etc ,worker id ,Location ,Delivery status
This project is made with love from Team 1
Parth Maheshwari 19BCT0221
Abhijeet Jaiswal 19BCT0191
Muzzammil Hussain 19BCT0162
Arkaprava Mahato 19BCT0173
Please Connect to Ropsten test Network


Supply Chain Service
HOME PRODUCTS WORKERS STATUS DATA
Sr. No. Product Name Product ID Description Price Required Temp. Manufacturing Date
1 crocin 0 sdf jsdkf ssdf ddd
2 Crocin 1 Fever Rs. 16 23.2C compA
3 Paracetamol 2 Pain R. 6 18C ABC
4 Zincovit 3 Pain R. 6 18C ABC


Supply Chain Service
HOME PRODUCTS WORKERS STATUS DATA
22
Product Status
whb
Sun Aug 14 2022 18:34:48
Temperature recorded: 23.3C°C
whb
Sun Aug 14 2022 18:42:36
Temperature recorded: 23.3C°C

CONCLUSION

So we successfully created a simulation for the pharmaceutical supply chain where data is transferred privately and in a secure way which is tamper proof and resistant to DDoS and other attacks which are very common in other platforms.
We used NodeRed , fastAPI and ReactJS. We also created a smart contract and all the data is stored in the blockchain.

LIMITATIONS

Permissioned Blockchains

Because supply chain information can be sensitive, a permissioned blockchain (that is, a blockchain that is not open to the public) is usually preferred. However, a permissioned system is less secure, because there are fewer nodes to make up the blockchain and those nodes are typically known to each other, resulting in an easier ability to collude to change a block.

The Human Element

While there is great value in all members of a supply chain knowing that the data on the blockchain cannot be changed once it is established, there can still be human error or intentional misconduct in inputting the initial data onto the blockchain. Therefore, blockchain data is not perfect information – it could be false or even fraudulent. For instance, a bad actor could fill a container with rocks and record on the blockchain instead that the container was filled with auto parts.

Blockchain technology could make it easier to detect at which stage in the supply chain the container was filled with rocks, but would not prevent the fraudulent data from hitting the blockchain in the first place. Essentially, blockchain technology does not prevent incorrect information from being entered onto the chain; it just allows every user on the blockchain to confirm that the data on the blockchain has not changed since a certain point in time.

Because blockchain technology is traditionally immutable, fraudulent data inserted onto the chain is problematic. Accenture has developed a prototype to allow authorities of permissioned blockchains to edit previous transactions in

extraordinary circumstances in order to resolve human error, although some blockchain technologists have criticized such approaches to blockchain, stating that erasing immutability defeats the purpose of using blockchain over a traditional database.

Scaling

Blockchain solutions are far slower to process transactions than traditional databases, because the transactions must be validated on many different computers or servers. In addition, due to the high volume of transactions in the supply chain, having a permissionless aspect of a blockchain solution could be costly, since transaction fees would need to be paid to fund the work performed by the miner nodes to create the blocks. Considering certain supply chains execute millions of transactions a day, the method in which blockchain technology is implemented must be thoughtfully approached with an eye towards scalability.

Upfront Costs

The upfront costs of implementing a blockchain solution have the potential to be steep. There are costs associated with hiring blockchain developers, which tend to cost more than traditional developers due to their specialized area of expertise. Planning costs, licensing costs, and maintenance costs can also contribute to a hefty price tag.

FUTURE ENHANCEMENTS

1. We can use some other blockchains other than ethereum as transaction fees in etherium is very high
2. We can add authentication to frontend app so only approved people can status of data
3. We can also use some other sensors like scanners or RFID to further add complex functionalities

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