Pharma Trace : Enhancing Drug Packaging System Using Blockchain Technology and Enhanced QR Code Scanning

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ABSTRACT:
Implementing QR codes on medicine packaging signifies a pivotal advancement in healthcare technology. By scanning these codes, users effortlessly unveil crucial details like the medicine's name, batch number, expiry date, and manufacturing date. This marriage of technology with pharmaceuticals aims to create a user-friendly ecosystem that not only enhances accessibility to medication information but also strengthens data security through the integration of blockchain technology. The utilization of blockchain ensures the immutability of the stored information, employing advanced hashing techniques to resist tampering and guarantee the integrity of the data. Moreover, the comprehensive system built around QR codes and blockchain provides a dynamic understanding of the pharmaceutical supply chain. Users can confidently trace the entire lifecycle of a tablet sheet, from its inception in the manufacturing phase to its final distribution state. This end-to-end visibility not only fosters transparency but also establishes a sense of accountability within the pharmaceutical industry. The innovative combination of QR codes and blockchain technology not only simplifies the user experience but also sets a new standard for reliability and trust in medication information. In essence, this transformative approach goes beyond the surface level of convenience, presenting a holistic solution that empowers individuals to make informed decisions in healthcare. The integration of QR codes and blockchain technology not only meets the demands of a user-centric system but also contributes to the evolution of a transparent and secure pharmaceutical landscape. As we embrace these technological strides, the collaboration between QR codes and blockchain becomes a cornerstone in reshaping the future of healthcare information accessibility and reliability.

INTRODUCTION

The global pharmaceutical industry faces critical challenges related to the authenticity and safety of medicines, especially in regions like Africa where improper dosing from counterfeit drugs results in over 100,000 deaths annually. The existing pharmaceutical supply chain struggles to ensure drug authenticity due to continuous ownership changes and the lack of connection between physical and information flows, making real-time traceability a costly practice for regulatory authorities. Consequently, patients often fall victim to the circulation of counterfeit drugs.

Addressing these issues, this research explores the transformative potential of Blockchain technology in the pharmaceutical supply chain. The Information and Communication Technology (ICT) landscape is undergoing significant advancements, and Blockchain, in particular, stands out for its potential to enhance end-to-end visibility, security, trust, and traceability in the pharmaceutical supply chain. The conventional challenges associated with the lack of visibility and traceability can be mitigated through the integration of Blockchain and IoT.

In response to vulnerabilities in current pharmaceutical packaging practices, concerted efforts are being made to establish robust rules and standards. The aim is to enhance the safety and

clarity of medicine packaging, reducing the infiltration of counterfeit drugs. This becomes especially crucial during times of crisis, such as the COVID-19 pandemic, where the demand for medicines increases, creating a higher risk of encountering substandard or fake products.
The pharmaceutical industry plays a pivotal role in global health, providing life-saving medications. However, the current lack of stringent rules and standards for medicine packaging poses a significant challenge. This research aims to contribute to the creation of a safer pharmaceutical supply chain by leveraging Blockchain and IoT technologies. Through the implementation of comprehensive guidelines and technological solutions, the objective is to uphold the quality of medicines, ensuring they are safe and genuine for patients worldwide.
In the pharmaceutical industry, ensuring the authenticity and safety of medications remains a top concern. However, the widespread circulation of counterfeit drugs, particularly common in regions such as Africa, poses significant challenges and puts public health at risk. The current state of the pharmaceutical supply chain is characterized by vulnerabilities and inefficiencies, leading to an increase in counterfeit products. Real-time traceability, crucial for ensuring drug authenticity, remains difficult to achieve, exacerbating these issues.
Taking inspiration from the tuna fish concept, where each tuna can be traced back to its source through a comprehensive tracking system, exploration is made into the potential of Blockchain technology to address the challenges faced by the pharmaceutical supply chain. Similar to the tuna fish industry's ability to trace individual fish back to their origins, Blockchain offers a promising solution for enhancing transparency, security, and traceability throughout the pharmaceutical supply chain.
By leveraging Blockchain technology, the goal is to establish a robust system that enables the tracking of pharmaceutical products from their manufacturing origin to their distribution endpoints. This comprehensive tracking system will strengthen medication authenticity, reduce the risks associated with counterfeit drugs, and ultimately improve patient safety.
Recognizing the pivotal role of the pharmaceutical industry in global health, efforts are made to contribute to the establishment of a safer pharmaceutical supply chain. Through the implementation of Blockchain technology and the adoption of principles akin to the tuna fish concept, this seeks to provide a framework for ensuring medication authenticity and promoting public health on a global scale.

LITERATURE REVIEW

The World Health Organisation (WHO) found that incorrect dosage from fake medications purchased from unidentified or unreliable suppliers causes more than 100,000 fatalities annually in Africa [1], [2]. The actors in the pharmaceutical supply chain are unable to fully ensure the authenticity of drugs due to two reasons: first, the supply chain does not link the physical and information flows of drugs, making it difficult to track where a product or drug is at any given time. Blockchain has the potential to improve supply chain visibility, tracing, tracking, and trust through smart contracts. As a result, it will improve how the pharmaceutical sector operates. Our concept is to utilise the benefits offered by blockchain and IoT to bring all these aspects to the supply chain [3, [4], [5].
Due to the significant quantity of information exchange required, blockchain solutions for non-financial applications and their integration into company strategy are encountering opposition. When deploying blockchain, it is imperative that all users/actors be involved, according to Perboli, G. et al. [6]. Mettler M. [7] spoke about Hyperledger, a cross-industry research network that includes Accenture, Cisco, Intel, IBM, Block Stream, and Bloomberg. The project, Counterfeit Medicines, was just established. The author of paper [8] outlines the difficulties and upcoming demands for product tracing in the pharmaceutical sector. The author also explains how blockchain technology provides the greatest and most efficient means of securely and effectively exchanging data throughout the whole product life cycle and supply

chain. According to A. Jabbari et al. [9], blockchain must do away with the need for reliable third parties and be tailored to the unique requirements of supply chains in terms of data requirements and potentially complicated supply chain structures in order to have a major impact on supply chain management. According to a Deloitte analysis [10], as electronic chips and sensors continue to advance in technology, they become more portable. This presents an opportunity for an organisation to connect sensors to real items in order to improve monitoring and, ultimately, detect fraud. Rebuilding Medicine Supply Chain Architecture using Blockchain Technology: Ensuring Authenticity and Privacy of Traceability Data" (Clark, 2021)

Clark's research investigates the application of blockchain technology to reshape the medicine supply chain, with a particular emphasis on ensuring authenticity and privacy of traceability data. The study establishes a robust foundation for blockchain data storage, incorporating smart contracts, Electronic Product Codes (EPCs), and algorithms. These components play a crucial role in creating and verifying contracts, ensuring the secure and private handling of traceability data within the medicine supply chain. "Blockchain Technology in the Pharmaceutical Supply Chain: Benefits, Challenges, and Limitations" (Flannigan & McBride, 2020) Flannigan and McBride's study explores the advantages of implementing blockchain technology in the pharmaceutical supply chain. Highlighting transparency, security, and data immutability, the research offers valuable insights into the benefits associated with blockchain adoption. Additionally, the study addresses challenges and limitations, providing a comprehensive perspective on the considerations involved in integrating blockchain into the pharmaceutical industry.

"Blockchain Technology for Ensuring Authenticity and Traceability in the Pharmaceutical Supply Chain: A Conceptual Framework" (Sawyer, Jimmerson, Bradley, Connors, & Ramirez, 2019) Sawyer et al. present a conceptual framework designed to incorporate blockchain technology into the pharmaceutical supply chain. The primary objective of this framework is to ensure the authenticity and traceability of pharmaceutical products. Addressing concerns related to data integrity and supply chain transparency, the study outlines a structured approach to leveraging blockchain for enhancing the reliability and security of pharmaceutical supply chains. "Design and Fabrication of Manufacturable Optical Filters based on Serial Ring Resonators" (Martinez, Fuentes, et al., 2019)

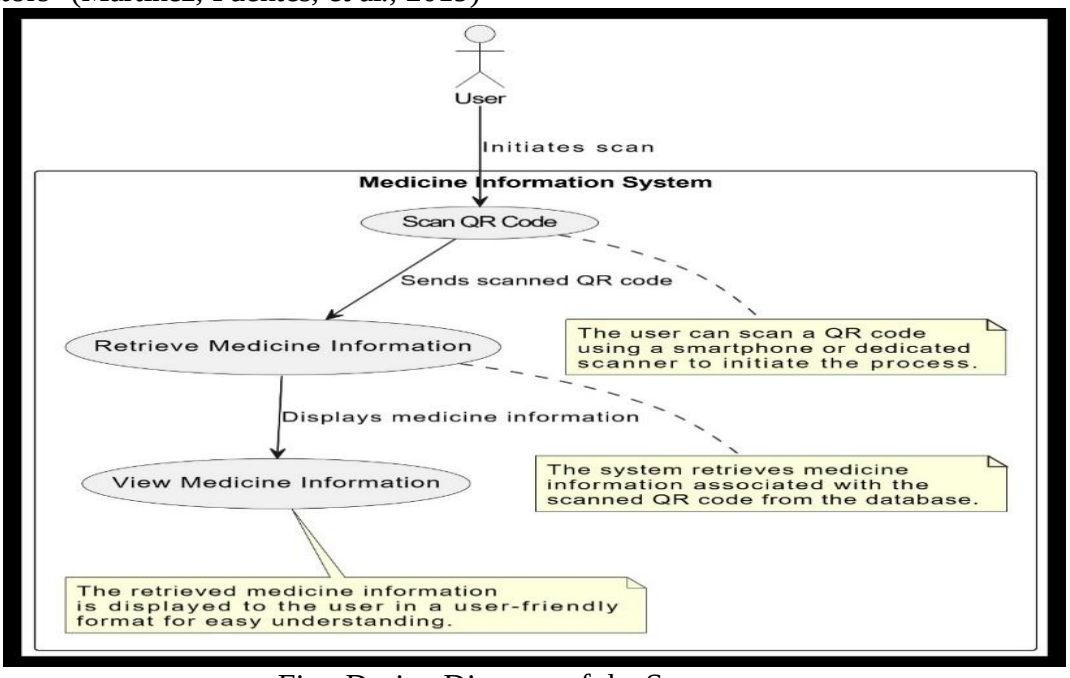

Fig : Design Diagram of the System

This is a Design diagram of a medicine information system. The system works by allowing users to scan a QR code on a medicine package using a smartphone or dedicated scanner. The scanned QR code is then sent to the medicine information system database. The system retrieves medicine information associated with the scanned QR code and displays it to the user in a user-friendly format.
This system could be helpful for people who want to learn more about a medication they are taking. It could also be useful for medical professionals who need to look up information about a medication quickly.
Here are some of the benefits of using a medicine information system:
It can help people get accurate information about their medications.
It can help people understand the risks and benefits of taking a medication.
It can help people make informed decisions about their healthcare.

ARCHITECTURAL DESIGN

Architectural view of entire proposed system is

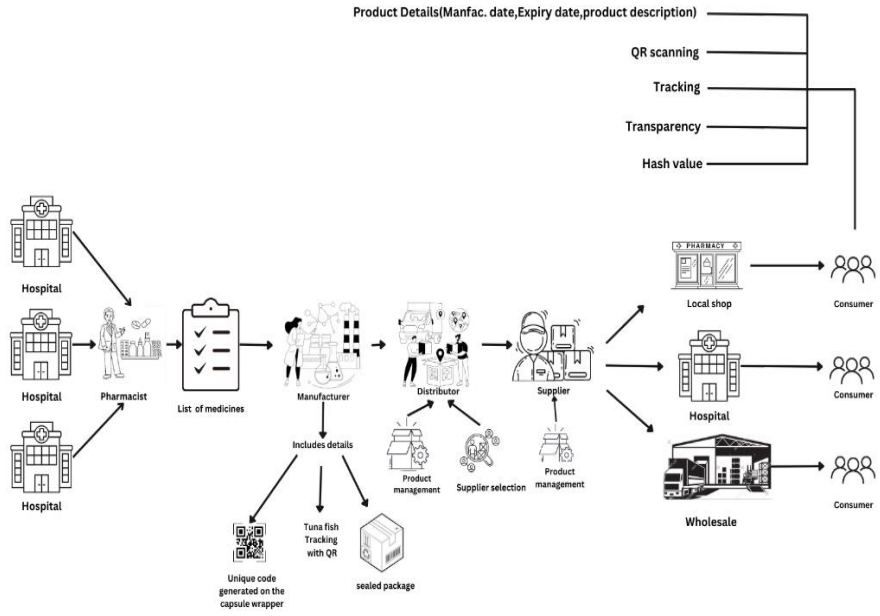

Fig : Architecture Diagram.

In this project, a manufacturer operates as the central hub for the production and distribution of medicines. Hospitals or pharmacists initiate the process by placing orders for specific medicines. Upon receiving orders, the manufacturer compiles a list of medicines and adds them to the production line, assigning each product a unique code. Integration with a system related to tuna fish is also implemented at this stage. The manufacturer then designates a unique code for distributors who receive the manufactured products. Distributors play a crucial role by checking the received products and adding details of the supplier. The suppliers take over next, managing the products and distributing them to local shops, hospitals, and wholesale buyers. Eventually, the products reach end users. Throughout this entire process, a QR code is generated for each product, containing essential details such as product ID, manufacturer name, distributor name, supplier name, expiry date, manufacturing date, cost,

and a unique ID. Additionally, manufacturing details of the product are included in the QR code, ensuring a comprehensive and traceable system from production to end-user delivery.

SAMPLE CODING

Register.sol :

```
// SPDX-License-Identifier: MIT
pragma solidity >=0.4.22 <0.9.0;

contract register {
  uint[] _dids;
  string[] _dnames;
  string[] _dcontacts;
  string[] _daddress;
  string[] _demails;
  string[] _dphones;
  string[] _dtins;
  string[] _dbrns;
  address[] _dwallets;
  string[] _demergency;
  string[] _dpasswords;

  uint[] _sids;
  string[] _snames;
  string[] _scontacts;
  string[] _saddress;
  string[] _semails;
  string[] _sphones;
  string[] _stins;
  string[] _sbrns;
  address[] _swallets;
  string[] _semergency;
  string[] _spasswords;

  string[] _productId;
  string[] _productName;
  string[] _manufacturerInfo;
  string[] _lotNumber;
  string[] _manufacturingDate;
  string[] _expirationDate;
  string[] _serialNumber;
  string[] _uid;
  uint[] _productstatus;

  string[] _tdistributor;
  string[] _tproduct;

  string[] _ssupplier;
  string[] _sproduct;

  address manufacturer;
```

```
  string manuPassword="1234";

  mapping(address=>bool) _registeredDistributors;
  mapping(address=>bool) _registeredSuppliers;
  mapping(string=>bool) _registeredProducts;

  constructor() {
    manufacturer=msg.sender;
  }

  modifier onlyManufacturer(){
    require(msg.sender==manufacturer);
    _;
  }

  function viewManufacturer() public view returns(address,string
memory){
    return (manufacturer,manuPassword);
  }

  function addDistributor(uint did,string memory dname,string memory
dcontact,string memory daddress,string memory demail,string memory
dphone,string memory dtin,string memory dbrn,address wallet,string
memory demergency,string memory dpassword) public onlyManufacturer{
    require(!_registeredDistributors[wallet]);

    _dids.push(did);
    _dnames.push(dname);
    _dcontacts.push(dcontact);
    _daddress.push(daddress);
    _demails.push(demail);
    _dphones.push(dphone);
    _dtins.push(dtin);
    _dbrns.push(dbrn);
    _dwallets.push(wallet);
    _demergency.push(demergency);
    _dpasswords.push(dpassword);

    _registeredDistributors[wallet]=true;
  }

  function viewDistributors() public view returns(uint[]
memory,string[] memory,string[] memory,string[] memory,string[]
memory,string[] memory,string[] memory,string[] memory,address[]
memory,string[] memory,string[] memory) {
    return(_dids,_dnames,_dcontacts,_daddress,_demails,_dphones,_dti
ns,_dbrns,_dwallets,_demergency,_dpasswords);
  }
```

```
  function addSupplier(uint sid,string memory sname,string memory
scontact,string memory saddress,string memory semail,string memory
sphone,string memory stin,string memory sbrn,address swallet,string
memory semergency,string memory spassword) public {
    require(!_registeredSuppliers[swallet]);

    _sids.push(sid);
    _snames.push(sname);
    _scontacts.push(scontact);
    _saddress.push(saddress);
    _semails.push(semail);
    _sphones.push(sphone);
    _stins.push(stin);
    _sbrns.push(sbrn);
    _swallets.push(swallet);
    _semergency.push(semergency);
    _spasswords.push(spassword);

    _registeredSuppliers[swallet]=true;
  }

  function viewSuppliers() public view returns(uint[]
memory,string[] memory,string[] memory,string[] memory,string[]
memory,string[] memory,string[] memory,string[] memory,address[]
memory,string[] memory,string[] memory) {
    return(_sids,_snames,_scontacts,_saddress,_semails,_sphones,_sti
ns,_sbrns,_swallets,_semergency,_spasswords);
  }

  function addProduct(
      string memory productid,
      string memory productname,
      string memory manufacturerinfo,
      string memory lotnumber,
      string memory manufacturingdate,
      string memory expirationdate,
      string memory serialnumber,
      string memory uid) public
  {

        require(!_registeredProducts[productid]);

        _productId.push(productid);
        _productName.push(productname);
        _manufacturerInfo.push(manufacturerinfo);
        _lotNumber.push(lotnumber);
        _manufacturingDate.push(manufacturingdate);
        _expirationDate.push(expirationdate);
        _serialNumber.push(serialnumber);
```

```
        _uid.push(uid);
        _productstatus.push(0);

        _registeredProducts[productid]=true;
  }

  function viewProducts() public view returns(string[]
memory,string[] memory,string[] memory,string[] memory,string[]
memory,string[] memory,string[] memory,string[] memory,uint[]
memory){
    return (
      _productId,
      _productName,
      _manufacturerInfo,
      _lotNumber,
      _manufacturingDate,
      _expirationDate,
      _serialNumber,
      _uid,
      _productstatus);
  }

  function sendtodistributor(string memory productid,string memory
distributorid) public {

    uint i;
    for(i=0;i<_productId.length;i++){
      if((keccak256(abi.encodePacked(productid)) ==
keccak256(abi.encodePacked(_productId[i])))){
        require(_productstatus[i]==0);
        _productstatus[i]=1;
        _tdistributor.push(distributorid);
        _tproduct.push(productid);
      }
    }
  }

  function viewDistribution() public view returns(string[]
memory,string[] memory){
    return(_tdistributor,_tproduct);
  }

  function sendtosupplier(string memory productid,string memory
supplierid) public {
    uint i;
    for(i=0;i<_productId.length;i++){
      if((keccak256(abi.encodePacked(productid)) ==
keccak256(abi.encodePacked(_productId[i])))){
        require(_productstatus[i]==1);
```

```
        _productstatus[i]=2;
        _ssupplier.push(supplierid);
        _sproduct.push(productid);
      }
    }
  }

  function viewSupply() public view returns(string[] memory,string[]
memory){
    return(_ssupplier,_sproduct);
  }

}
```

RESULTS

Pre loader Page

The website will starts by this Pre loader.

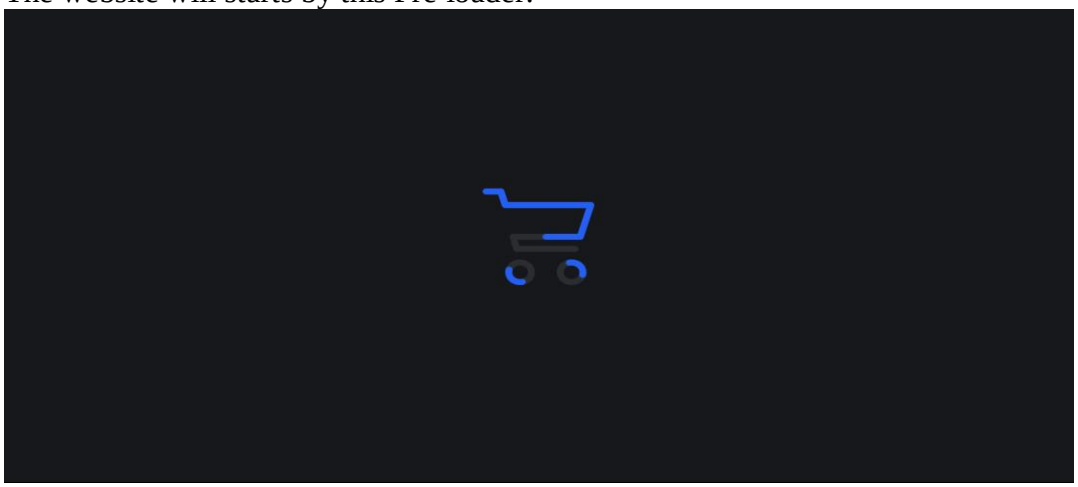

Figure : Pre loader

User Page

This page is for User. User can Scan the QR which prints on the product or he can search by product ID for getting details of the product.

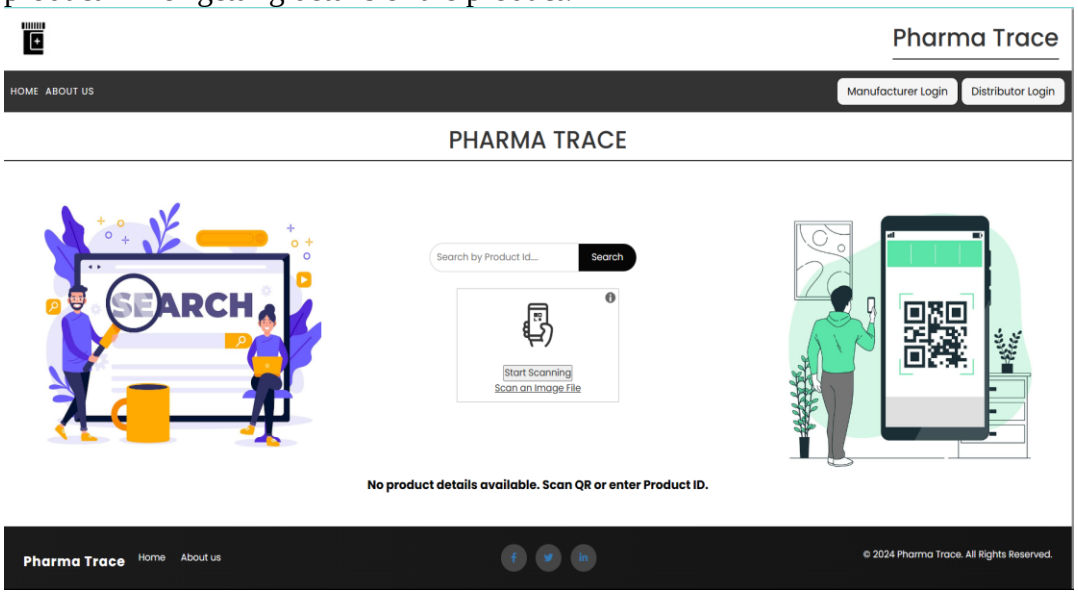

Figure : User Page

About Us Page

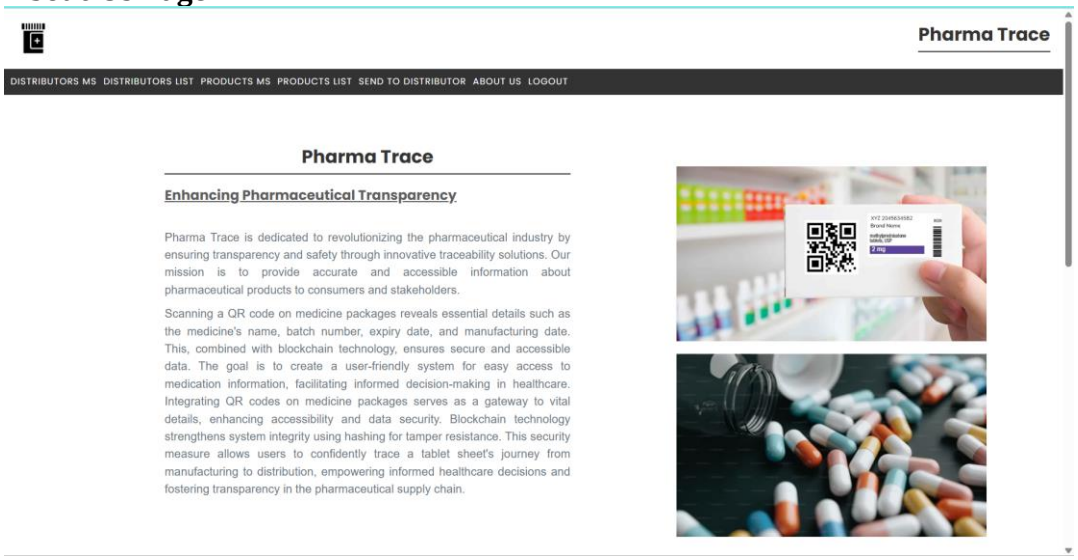

Figure : About Us Page

Manufacturer Login :

Manufacturer has Wallet Address and Password which is created already , if new manufacturer comes then Manufacturer Admin will adds the new manufacturer details.

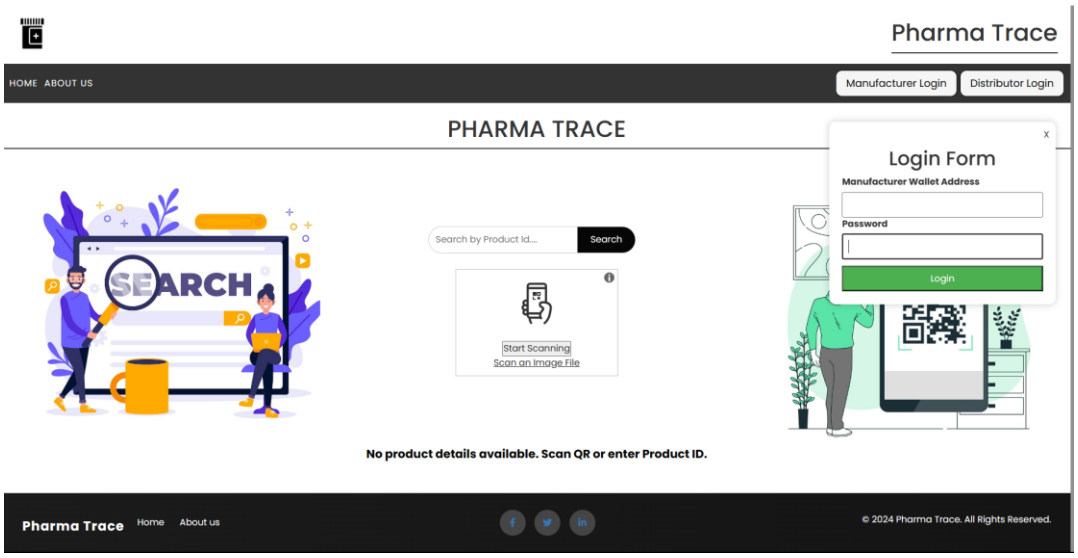

Figure: Manufacturer Page

CONCLUSION

In conclusion, the Pharma Trace system, inspired by the Tuna Fish Algorithm, revolutionizes pharmaceutical supply chain management with its innovative use of Blockchain, QR codes, and IoT technology. This comprehensive solution ensures the authenticity and safety of medicines from production to distribution. By applying the principles of the Tuna Fish Algorithm to tablet manufacturing, the system promotes ethical practices and transparency throughout the supply chain. The integration of Blockchain facilitates a secure and tamper-proof record-keeping system, enhancing transparency and traceability. Smart contracts enforce ethical standards, ensuring tablets are sourced and distributed responsibly. The real-time tracking provided by IoT devices adds another layer of accuracy and transparency to the entire process.

Consumers benefit significantly from this system. By simply scanning the QR codes on tablet packaging, they gain instant access to vital information about the tablet's origin, authenticity, and compliance with ethical standards. This user-friendly approach empowers consumers to make informed and responsible purchasing decisions. Overall, the Pharma Trace system, guided

by the Tuna Fish Algorithm, acts as a deterrent to illegal activities in the pharmaceutical supply chain. It not only enhances supply chain transparency and consumer empowerment but also lays the foundation for a safer and more accountable pharmaceutical industry. This amalgamation of cutting-edge technologies promises a future where medicine safety is prioritized, and stakeholders have easy access to essential details through a seamless scanning process.

FUTURE ENHANCEMENTS

In the dynamic landscape of the pharmaceutical supply chain, continuous improvement and adaptation to emerging technologies are crucial. Here are some potential future enhancements for your pharmaceutical supply chain project:

Enhanced Blockchain Integration:

Explore advanced blockchain features, such as smart contracts for automating supply chain transactions. This could streamline processes like payment settlements, product recalls, and compliance checks.

IoT Integration for Real-Time Monitoring:

Integrate Internet of Things (IoT) devices for real-time monitoring of pharmaceutical products. This could include temperature and humidity sensors, ensuring the integrity of products throughout the supply chain.

AI-Powered Predictive Analytics:

Implement artificial intelligence (AI) algorithms for predictive analytics. This can help anticipate potential supply chain disruptions, optimize inventory management, and enhance decision-making processes.

Expanded Mobile Applications:

Enhance the functionality of mobile applications for consumers. Include features like personalized medication reminders, access to detailed drug information, and the ability to report adverse reactions or counterfeit products.

Supply Chain Collaboration Platform:

Develop a collaborative platform for stakeholders in the pharmaceutical supply chain. This platform could facilitate real-time communication, data sharing, and collaborative problem-solving to address challenges collectively.

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