VIVEKANAND EDUCATION SOCIETY'S INSTITUTE OF TECHNOLOGY

(An Autonomous Institute Affiliated to University of Mumbai)

Department of Computer Engineering

Project Report on

Drug Inventory and Supply Chain Tracking System

Submitted in partial fulfillment of the requirements of the degree

BACHELOR OF ENGINEERING IN COMPUTER ENGINEERING

By

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(AY 2023 - 24)

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Certificate

This is to certify that the Mini Project entitled " Drug Inventory and Supply Chain Tracking System" is a bonafide work of **Simran Ahuja (D17C - 02), Jesica Bijju (D17C - 10), Sejal Datir (D17C - 14) and Sania Khan(D17C - 36)**, submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of **"Bachelor of Engineering"** in **"Computer Engineering".**

Dr. (Mrs.) Nupur Giri	**Dr. (Mrs.) J. M. Nair**
Mentor, Head of Department	Principal

Mini Project Approval

This Mini Project entitled **“Drug Inventory and Supply Chain Tracking System”** by **Simran Ahuja (D17C - 02), Jesica Bijju (D17C - 10), Sejal Datir (D17C - 14) and Sania Khan(D17C - 36)** is approved for the degree of **Bachelor of Engineering** in **Computer Engineering.**

Examiners

1. ………………………………

(Internal Examiner name & sign)

2. ………………………………

(External Examiner name & sign)

Date: 23rd October, 2024

Place: Chembur, Mumbai

Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Date: 23rd October 2024

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Chapter I: Introduction

1.1 Introduction

The efficient management of drug supply chains is critical for ensuring the timely availability of essential medications in healthcare institutions. The current landscape of drug procurement and distribution often faces challenges such as inefficiencies, delays, and a lack of visibility into the movement and consumption of pharmaceuticals. To address these challenges, a new, innovative system—**the Drug Inventory and Supply Chain Tracking System**—is proposed.

The system is designed with the core objective of delivering the "Right Quantity" of the "Right Product" at the "Right Place," at the "Right Time," in the "Right Condition," at the "Right Cost," and to the "Right People." This holistic approach ensures that every step in the drug supply chain—from procurement to distribution and consumption—operates seamlessly, without delays or disruptions.

The primary goals of this system are to improve the efficiency and effectiveness of procurement and distribution processes through robust quality controls and to provide a dashboard-based online monitoring solution for real-time tracking. By focusing on these areas, the system will enable better decision-making, streamline vendor management, and enhance the monitoring of drug consumption patterns at hospitals and medical institutions. This will ensure the continuous availability of drugs and optimize drug distribution in a cost-effective manner.

Ultimately, the **Drug Inventory and Supply Chain Tracking System** will play a pivotal role in safeguarding public health by improving the transparency and responsiveness of the entire drug supply network.

1.2 Motivation

The motivation behind the **Drug Inventory and Supply Chain Tracking System** stems from the critical need to address inefficiencies in the existing pharmaceutical supply chains. Ensuring the consistent availability of life-saving drugs in healthcare institutions is a significant challenge, particularly in times of high demand or emergency situations. Hospitals and medical institutions often struggle with issues such as stock shortages, delayed shipments, lack of real-time monitoring, and inadequate transparency in vendor activities. These inefficiencies can lead to delayed patient care, increased healthcare costs, and even preventable fatalities.

- **Ensuring Drug Availability:** One of the primary drivers for this project is the need to ensure the uninterrupted supply of essential medicines to healthcare institutions. A robust system is essential to prevent shortages that can jeopardize patient care and outcomes.
- **Streamlining Procurement and Distribution:** Current drug procurement and distribution processes can be cumbersome, prone to human error, and susceptible to delays. This project

aims to streamline these activities, automate tracking, and provide real-time visibility into every stage of the supply chain, from ordering to delivery.

- **Quality Control and Safety:** The pharmaceutical industry is highly regulated, and ensuring the quality and safety of drugs is of utmost importance. The system aims to enhance monitoring by tracking environmental conditions such as temperature and humidity during transit, ensuring that drugs are delivered in optimal condition.
- **Vendor Accountability:** Effective vendor management is crucial for timely deliveries and maintaining supply chain efficiency. By providing transparency into vendor activities, such as shipment tracking, preparation of supply orders, and compliance with regulations, the system fosters greater accountability and performance monitoring.
- **Data-Driven Decision Making:** Healthcare institutions require real-time data on drug consumption patterns to make informed decisions about procurement, stock levels, and budget allocations. The system's dashboard and analytics tools will offer valuable insights, allowing hospitals to optimize their inventories, reduce wastage, and improve financial planning.
- **Cost Reduction:** Inefficiencies in drug supply chains often lead to higher operational costs, which can ultimately be passed on to patients. By implementing a more efficient and transparent system, this project aims to reduce unnecessary expenditures, benefiting both healthcare providers and patients.
- **Adapting to Emerging Needs:** The COVID-19 pandemic highlighted the vulnerability of global and local pharmaceutical supply chains. The system will be designed to be adaptable and resilient in the face of such public health emergencies, ensuring that the distribution of drugs can continue smoothly even during crises.

1.3 Drawback of existing systems

The current drug inventory and supply chain management systems used by healthcare institutions and pharmaceutical industries often face several limitations. These inefficiencies and shortcomings hamper the seamless distribution of drugs, affecting the overall healthcare delivery system. Some key drawbacks include:

- **Lack of Real-Time Visibility:** Existing systems often fail to provide real-time visibility into the movement and status of drugs throughout the supply chain. This lack of transparency can lead to delays in identifying stock shortages or shipment delays, resulting in stockouts or overstocking of drugs.
- **Inefficient Inventory Management:** Many healthcare institutions rely on manual processes or outdated systems to manage their inventory. This can result in inaccurate tracking of stock levels, leading to either excess inventory (which increases storage costs) or insufficient inventory (which jeopardizes patient care).

- **Fragmented Vendor Communication:** Communication with suppliers and distributors is often fragmented, leading to misaligned orders, delays in shipments, or incorrect quantities being delivered. Without a centralized platform for vendor management, monitoring vendor performance and ensuring accountability is challenging.
- **Lack of Integration Between Systems:** Healthcare organizations often use multiple, disconnected systems for procurement, inventory management, and distribution. These siloed systems do not share data efficiently, resulting in delays, miscommunication, and data inconsistency across different stages of the supply chain.
- **Limited Monitoring of Drug Conditions:** Maintaining the integrity of drugs during transportation is critical, especially for temperature-sensitive medicines like vaccines and biologics. Existing systems often lack the ability to monitor environmental factors such as temperature and humidity during transit, leading to compromised drug quality upon arrival.

1.4 Problem Definition

With the aim to provide "Right Quantity of "Right Product" on "Right Place" on "Right Time" in "Right Condition" at "Right Cost" for "Right People" and also to streamline the distribution of drugs to institutions and ensure availability of drugs at all times, a new, innovative system named Drug Inventory and supply chain Tracking system is required: To improve efficiency and effectiveness of procurement and distribution systems through robust quality controls To provide dashboard based online monitoring of all activities at each level Tracking of vendor activities like preparation of Supply Order, Shipment etc. Monitoring of Drug consumption pattern at the Hospitals/Medical Institutions Level

1.5 Relevance of the project

The **Drug Inventory and Supply Chain Tracking System** is highly relevant in today's healthcare landscape, where the efficient and reliable distribution of medicines is critical to patient care and public health. The relevance of this project stems from several key factors:

- **Ensuring Timely Drug Availability:** Hospitals, clinics, and pharmacies rely on a constant supply of medications to treat patients. Delays or stockouts can have serious consequences, including treatment interruptions and negative health outcomes. The proposed system addresses this issue by ensuring that drugs are available in the right quantity, at the right time, and in the right place, thus improving patient care.
- **Addressing Healthcare Challenges Post-Pandemic:** The COVID-19 pandemic highlighted the vulnerability of pharmaceutical supply chains, where sudden demand spikes led to shortages of essential drugs and medical supplies. This project is especially relevant in the context of improving supply chain resilience and preparedness for future public health emergencies by ensuring real-time tracking and adaptability.

- **Adoption of Digital Solutions in Healthcare:** Healthcare is increasingly moving toward the adoption of digital solutions for better management and optimization. The Drug Inventory and Supply Chain Tracking System aligns with this trend, providing a digital, automated, and data-driven solution that enhances operational efficiency, reduces manual errors, and improves the overall management of pharmaceutical inventories.

1.6 Methodology used

- **Identification of Supply Chain Entities**: Key entities involved in the drug supply chain (manufacturers, distributors, transport providers, medical institutions, and regulatory authorities) are identified to create a seamless flow of operations.
- **Dashboard Design & Data Visualization**: Custom dashboards are developed for each entity, incorporating real-time data analytics and visualizations to monitor drug availability, shipments, and consumption patterns.
- **Smart Contracts Development**: Smart contracts are written to automate transactions and verify drug authenticity at every stage, ensuring secure and transparent interactions between stakeholders.
- **Blockchain Integration**: Data related to drug manufacturing, distribution, and consumption is securely logged on the blockchain, providing an immutable audit trail and end-to-end traceability.
- **AI/ML-Powered Analytics**: Machine learning models are employed for predictive analytics, such as demand forecasting, anomaly detection, and automated reordering, to improve supply chain efficiency.

Chapter II: Literature survey

2.1 Research Papers

Paper [1] used a methodology to develop a framework incorporating smart contracts in which blockchain network architectures were identified, followed by designing smart contract algorithms, and then testing these contracts on the Ethereum Blockchain using Solidity and the Etherscan. A method to explore the implementation of blockchain in supply chain management, paper [2] highlights a gap in management-focused studies utilizing a qualitative exploratory approach, the study involved systematic data collection from various academic sources, resulting in the selection of 40 peer-reviewed documents. The paper [3] proposes a framework for eliminating intermediaries and utilizing Ethereum smart contracts to secure transaction monitoring, payment dispersal, and consumer notifications regarding the status of IoT containers,while also addressing consumer refunds in cases of con-tract breaches to ensure safe delivery of medicines. Paper [4] focusses on its applications in the food, agriculture, and pharmaceutical sectors, and presents a case study of Lenovo to illustrate the advantages of blockchain technology, proposing a conceptual model for a information collaboration system. Paper [5] analyzes 2,265 articles particularly highlighting traceability as a key driver of BCT applications in supply chain management and reveals significant growth in health-care, and government sectors, while a decline in banking and cyber security research, with insights pointing to China,the U.S., and India as leading contributors. The application of smart contracts and blockchain technology in maritime logistics is investigated in paper [6], highlighting the po-tential benefits of blockchain smart contracting systems in charter-party contracting processes and the operational effi-ciency of small and medium-sized ports. The study in paper [7] employed a systematic literature review (SLR) method-ology to analyze articles related to blockchain technology in supply chain (SC) management, following established protocols and adapting specific search strategies. The solution in paper [8] uses Hyperledger Fabric, involving key stakeholders such as pharmaceutical companies, the Drug RegulatorAuthority, and local vendors. By integrating on-chain re-sources for tracking events via smart contracts and off-chain resources for decentralized identity management, the sys-tem ensures efficient governance, security, and transparency,utilizing SHA-256 for hashing and ECC for cryptographic signing and verification of transaction data. Paper [9] investigates the integration of blockchain technology in logistics management, highlighting its role in enhancing transparency and reducing fraud. By utilizing a case study approach, the paper illustrates the tangible benefits of implementing blockchain solutions in logistics, including reduced operational costs and increased customer satisfaction. Paper [10] conducts a systematic literature review of 65 interdisciplinary articles published from 2010 to 2021,identifying key drivers and barriers to Blockchain adoption in Pharmaceutical Supply Chains (PSC). It highlights critical applications such as combating drug counterfeiting and addressing recall issues. The analysis reveals that research in this area has gained momentum, particularly since the Covid-19 pandemic.

2.2 Books / Articles referred / news paper referred

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6. Robert Philipp, Gunnar Prause, and Laima Gerlitz. Blockchain and smart contracts for entrepreneurial collaboration in maritime supply chains. Transport and Telecommunication, 20(4):365–378, 2019.

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Chapter III: Requirement Gathering for the Proposed System

3.1 Functional Requirements

User Roles & Permissions:

- Multiple users with different roles: Manufacturer, Distributor, Retailer, Pharmacy, Medical Institution, Customer, Regulatory Authorities, and Transport Providers.
- Each user can view and manage their specific dashboard with restricted access to certain functionalities based on their roles.

Drug Inventory Management:

- Track and manage drug inventory at various points in the supply chain (manufacturer, distributor, hospital).
- Update and view available stock, drugs in transit, and drugs received at different stages.

Transaction History:

- Store a complete, immutable history of drug transactions across the supply chain.
- Allow manufacturers to issue and transfer drug batches with real-time tracking.

Blockchain Integration:

- Use Ethereum Blockchain to record drug transactions and ensure transparency.
- Smart contracts to verify and authorize transactions between different entities (e.g., between manufacturer and distributor, distributor and hospital).

Drug Order Placement and Payment:

- Enable pharmacies, hospitals, or other institutions to place drug orders and make payments using Razorpay or cryptocurrency (ETH).

Smart Contract Interactions:

- Create, update, and deploy smart contracts that define rules for drug ownership, transfer, and verification.
- Enable verification of drug authenticity by fetching batch details using Web3.js.

Batch Tracking & Reporting:

- Real-time tracking of drug batches using blockchain-based data.

- Generate reports or charts using Charts.js for insights on stock levels, drug usage, and transactions.

Regulatory Compliance Monitoring:

- Ensure that regulatory bodies can monitor transactions to verify compliance with legal standards.
- Provide detailed transaction records on-demand to authorized users.

Metamask Wallet Integration:

- Use Metamask for connecting user wallets for transactions.
- Users can view their account balance and perform blockchain-based drug purchase or transfer using their Metamask wallet.

3.2 Non-Functional Requirements

Security:

- Ensure secure access to the system via login with authentication and role-based access controls.
- Use blockchain for immutability, ensuring that transactions cannot be tampered with.
- Metamask wallet provides secure user interaction for financial transactions.

Scalability:

- The system should scale to accommodate multiple users and drug orders, handling large amounts of data as the number of transactions grows.
- Use of IPFS for decentralized file storage, reducing server load.

Performance:

- Ensure fast query and transaction processing through optimized interaction with blockchain and the smart contract.
- Implement caching strategies for frequently accessed data (e.g., drug details).

Reliability:

- The system must provide accurate, real-time updates of drug batch status across the supply chain.
- Ensure that the smart contracts and blockchain interactions are highly reliable, with transactions successfully recorded and stored permanently.

3.3 Constraints

Blockchain Transaction Speed:

- Ethereum blockchain transactions can have latency due to network congestion and gas fees. Ensure gas optimization and monitor performance during peak hours.

Gas Fees:

- Ethereum requires gas fees for smart contract transactions, which might fluctuate and need to be considered for cost management.

Regulatory Compliance:

- The system must comply with legal regulations for drug tracking and medical data privacy in the regions where it operates.

Metamask Wallet Dependency:

- Users must have Metamask installed to perform blockchain-based transactions, which limits accessibility to users familiar with crypto wallets.

3.4 Hardware & Software Requirements

Hardware Requirements	Software Requirements
GPS Devices: For tracking the location of shipments.	**Frontend:** React.js, HTML5, CSS3, JavaScript **Backend:** Solidity (Smart Contracts), Python
Barcode/RFID Scanners: To scan drugs at various points in the supply chain.	**Blockchain:** Ethereum/Hyperledger, Web3.js or Ethers.js

3.5 Tools utilized till date

Blockchain Development Tools:

- **MetaMask:** For interacting with Ethereum blockchain and managing accounts.
- **Ganache:** Local blockchain for testing smart contracts.
- **Truffle:** Development framework for smart contract compilation, migration, and testing.

Web Development Tools:

- **React.js:** For building the frontend, creating interactive dashboards and components.
- **HTML5/CSS3:** Basic structure and styling of the web pages.
- **JavaScript:** Core scripting language for frontend logic.
- **React Router:** For navigation and managing different views in the application.
- **Chart.js/D3.js:** For visualizing data like inventory levels or sales performance.

3.6 Project Proposal

1. **Inventory Management**:
   - Efficient, real-time management of drug stock levels across various stakeholders (manufacturers, distributors, hospitals, pharmacies).
   - Automated alerts for low stock levels and impending expirations to ensure timely replenishment and minimize drug wastage.
2. **RFID-Based Tracking & Drug Verification**:
   - Use of RFID tags to track the movement of drugs across the supply chain, from manufacturing to distribution and delivery.
   - Ensures authenticity, prevents counterfeit drugs, and offers real-time updates on drug locations.
3. **AI/ML-Based Predictive Analytics**:
   - AI models forecast drug demand, predict consumption patterns, and detect anomalies in drug usage.
   - Helps avoid overstocking or stock outs by offering accurate demand predictions and facilitating automated procurement.
4. **Shipment Tracking**:
   - Real-time monitoring of drug shipments, with tracking from manufacturers to distributors, hospitals, and pharmacies.
   - Alerts for delays, potential risks, or deviations in delivery schedules.
5. **ERP Integration**:
   - Seamless integration with existing ERP systems for managing procurement, inventory, and distribution operations.
   - Streamlines processes and offers better control over financial and logistical aspects of the supply chain.

Advanced Services:

1. **Blockchain-Based Transaction Verification**:
   - Use of a decentralized ledger to maintain a transparent, tamper-proof record of all transactions and drug movements across the supply chain.

- Automated smart contracts enable secure, fast, and automated transactions between entities.

2. **Smart Contracts**:
    - Automated contracts for drug transfers, payments, and shipment confirmations between stakeholders.
    - Reduces manual intervention and ensures secure, immutable agreements.
3. **Data-Driven Report Generation**:
    - Generation of detailed reports on drug usage, inventory levels, vendor performance, and more.
    - Customizable reports can be tailored to specific time frames, drugs, suppliers, or consumption trends.
4. **Customizable Dashboard Views**:
    - Dashboards tailored for different entities (manufacturers, distributors, hospitals, pharmacies) with data visualizations and analytics.
    - Allows stakeholders to monitor key metrics like stock levels, shipment status, and regulatory compliance.
5. **Automated Procurement & Reordering**:
    - AI-driven reordering process automatically initiates drug procurement based on consumption patterns and predicted demand.
    - Ensures optimal stock levels and reduces the risk of shortages.
6. **Vendor Performance Monitoring**:
    - Evaluation and tracking of supplier performance using predefined metrics.
    - Helps in identifying reliable vendors and ensuring timely deliveries.
7. **Supply Chain Risk Management**:
    - Proactive monitoring of risks such as transportation delays, supplier shortages, and compliance issues.
    - Mitigation strategies are applied to minimize disruptions in the supply chain.
8. **Counterfeit Drug Detection**:
    - System flags counterfeit drugs using blockchain and RFID data, ensuring only authentic drugs are delivered to stakeholders.

Analytics & Visualization:

1. **Real-Time Data Analytics**:
    - Dashboards provide stakeholders with real-time insights into drug stock, usage trends, and operational performance.
2. **Customizable Reporting Tools**:
    - Tools for generating custom reports that can focus on various parameters such as time frames, drug batches, or supplier performance.
3. **Data-Driven Decision Support**:

    - Analytics-driven decision support for optimizing drug purchases, stock levels, and supply chain operations.
4. **KPI Monitoring**:
    - Tracking and visualization of key performance indicators (KPIs) such as drug availability, delivery times, and consumption rates.
5. **Inventory Heatmap**:
    - A visual representation of drug stock availability across different locations, enabling easy identification of areas with low inventory.

Regulatory & Security Services:

1. **Audit Trail**:
    - Complete audit history for every transaction and drug movement within the supply chain.
    - Ensures regulatory compliance and provides full traceability of drug batches.
2. **End-to-End Traceability**:
    - Full traceability of each drug batch from manufacturing through to delivery, ensuring complete transparency across the supply chain.
3. **Multi-Language Support**:
    - The system offers multilingual support, with dashboards and reports available in various languages to cater to global stakeholders.
4. **Automated Regulatory Reporting**:
    - Automatic generation of reports for regulatory authorities, ensuring compliance with legal and safety standards in the pharmaceutical industry.

System Workflow:

1. **Manufacturing and Inventory**:
    - Manufacturers log drug production details into the system, including batch numbers, production dates, and expiry information.
    - RFID tags are assigned to each batch, ensuring real-time tracking across the supply chain.
2. **Distribution and Shipment**:
    - Distributors and hospitals place orders for drugs, with the system automatically generating orders based on predicted demand.
    - Shipments are tracked in real-time, and delays or deviations trigger alerts for stakeholders.
3. **AI-Driven Analytics**:

    - AI and machine learning algorithms monitor drug usage, forecast demand, and provide insights on procurement and reordering strategies.
4. **Smart Contracts and Blockchain**:
    - Transactions between entities, such as drug transfers and payments, are executed through smart contracts, with all data securely stored on the blockchain.
5. **Real-Time Reporting and Monitoring**:
    - Stakeholders have access to real-time dashboards for monitoring stock levels, shipment status, and compliance metrics.
    - Reports can be generated for auditing purposes or to meet regulatory requirements.

Chapter IV: Proposed Design

4.1 Block diagram of system

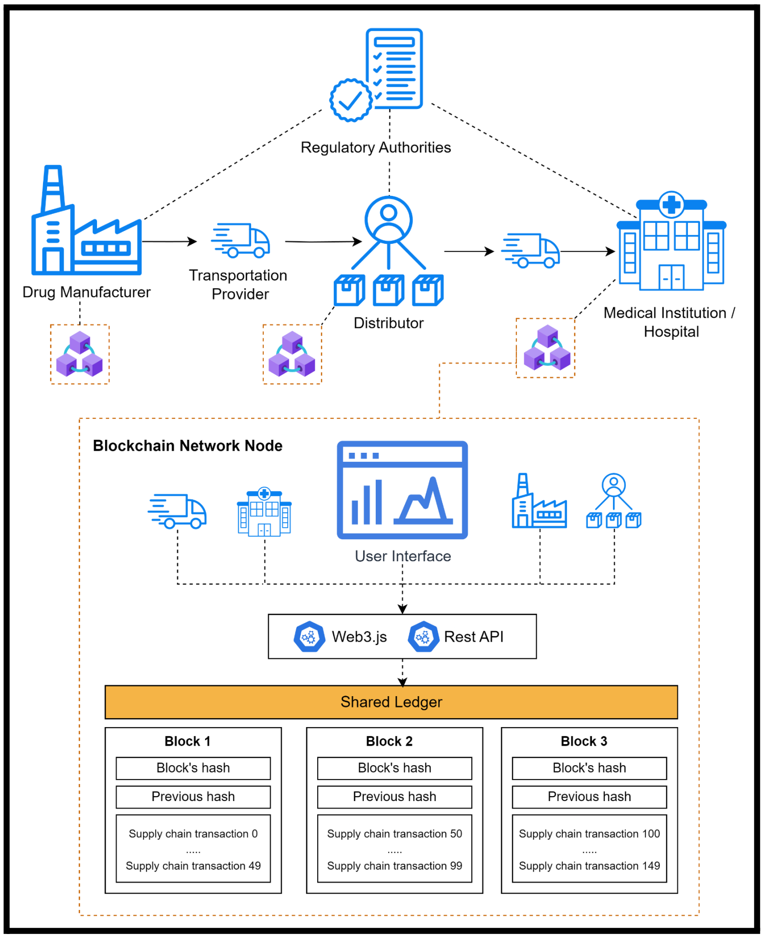

Fig. 1: Block diagram

Explanation of Entities:

- **Drug Manufacturer**: Responsible for producing drugs, the manufacturer logs details of each batch into the blockchain, ensuring transparency and traceability.
- **Distributor**: Acts as the intermediary, handling the distribution of drugs from manufacturers to hospitals and pharmacies, while recording transactions on the blockchain.
- **Transportation Provider**: Facilitates the shipment of drugs, ensuring their safe delivery from manufacturer to distributor or medical institutions, with real-time tracking.
- **Medical Institution/Hospital**: Receives the drugs and ensures they are administered correctly, recording consumption data to the shared ledger.
- **Regulatory Authorities**: Oversee the entire supply chain, ensuring compliance with regulations, and have access to audit trails for each transaction.
- **Blockchain Network Node**: Stores transaction records on a decentralized ledger, with smart contracts automating drug transfers and payments between entities.

4.2 Modular design of the system

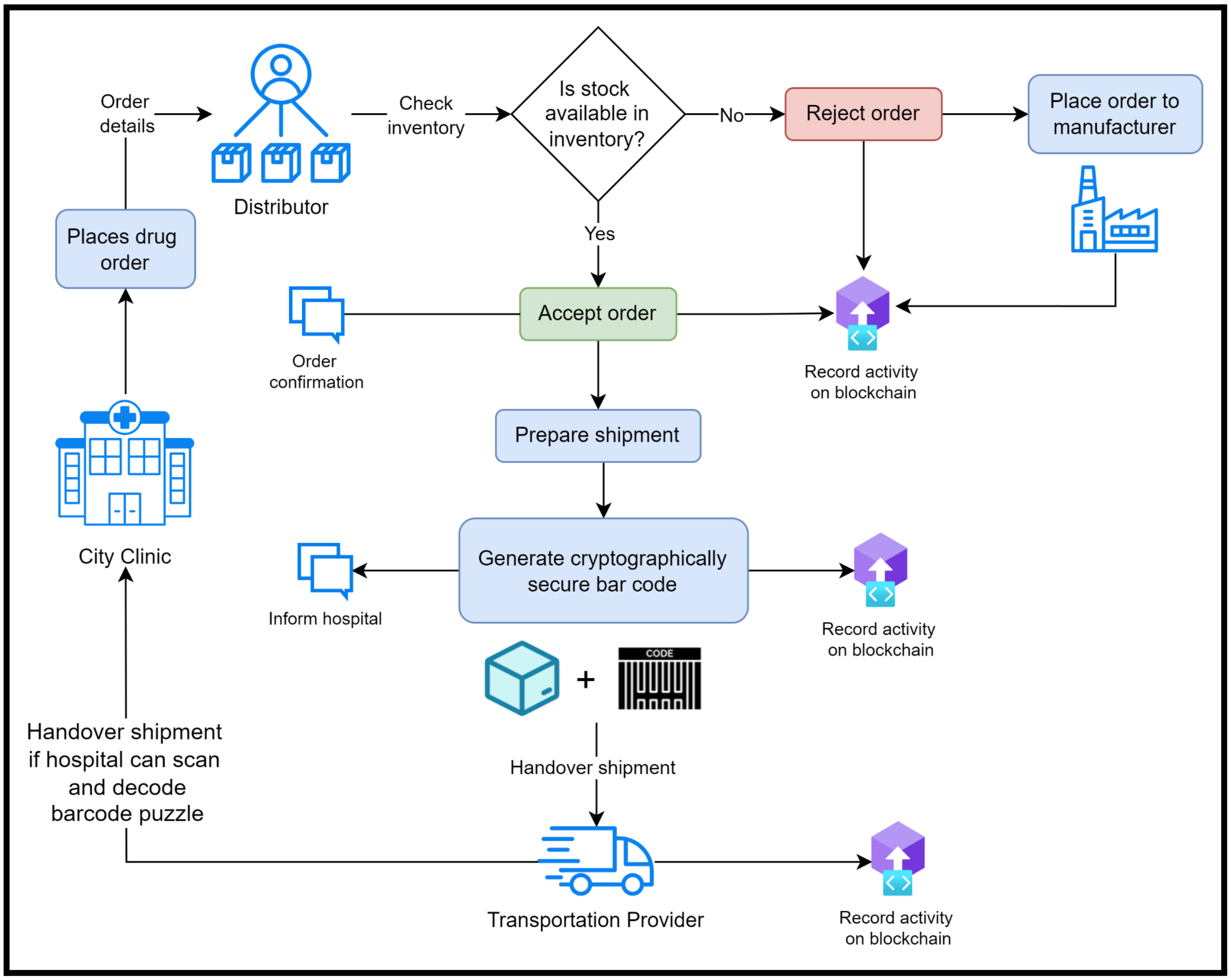

Fig. 2: Modular Design

4.3 Design of the proposed system

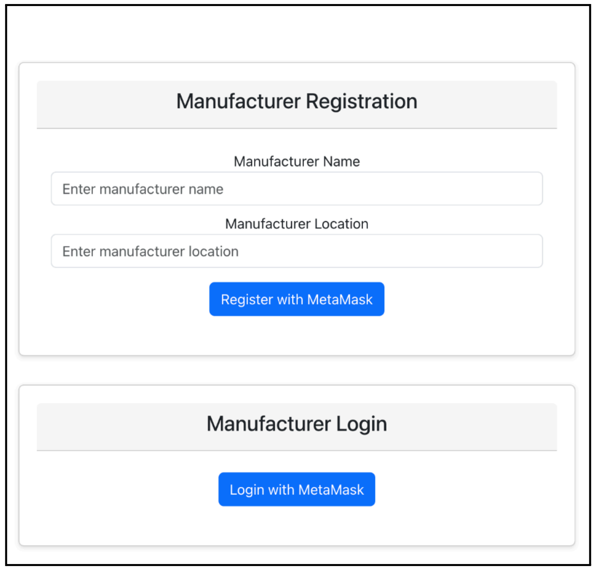

Fig. 3: Manufacturer's Dashboard - Login Page (With Metamask)

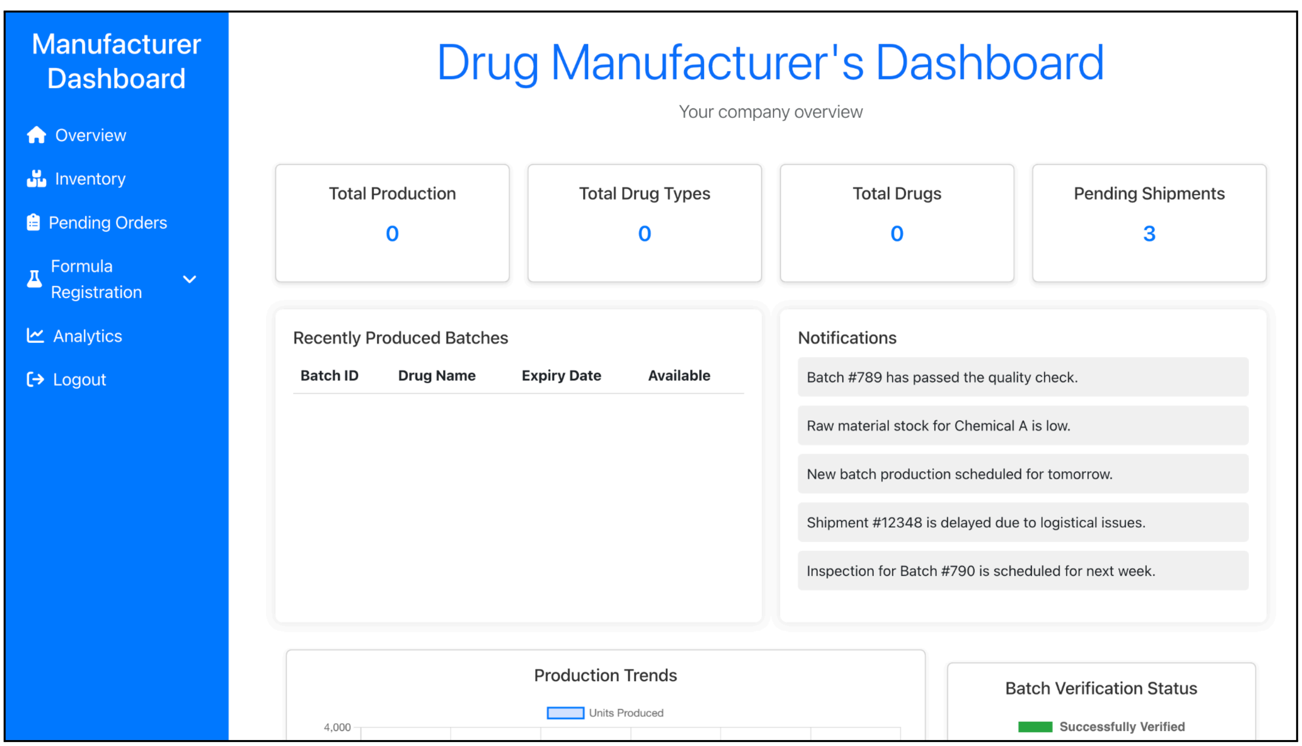

Fig. 4: Manufacturer's Dashboard

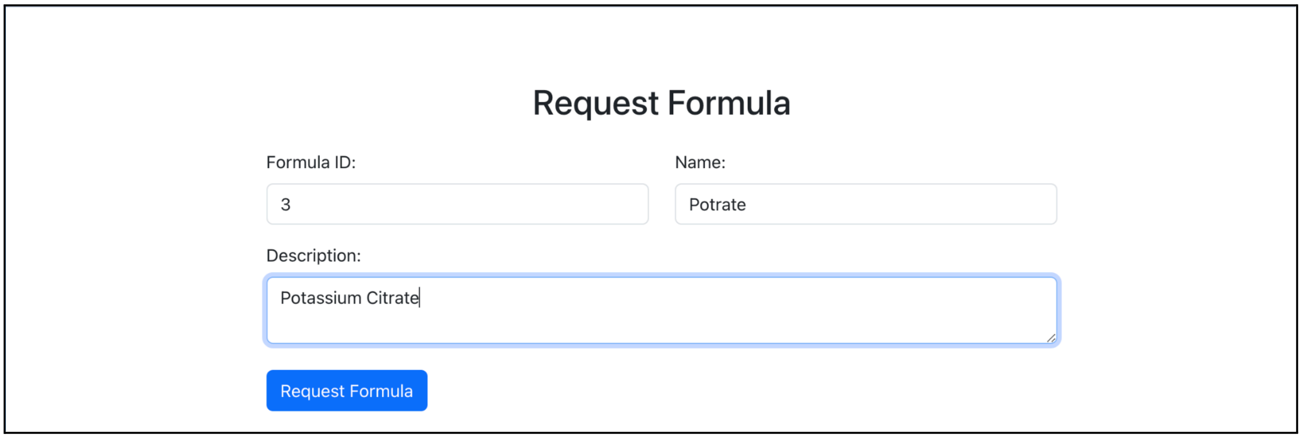

Fig. 5: Manufacturer’s Dashboard - Page to Request Drug formulae

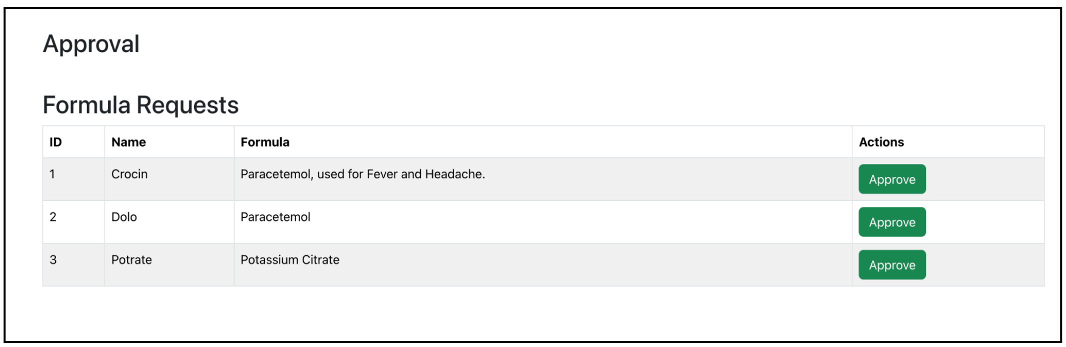

Fig. 6: Manufacturer’s Dashboard - Page to Approve Requests

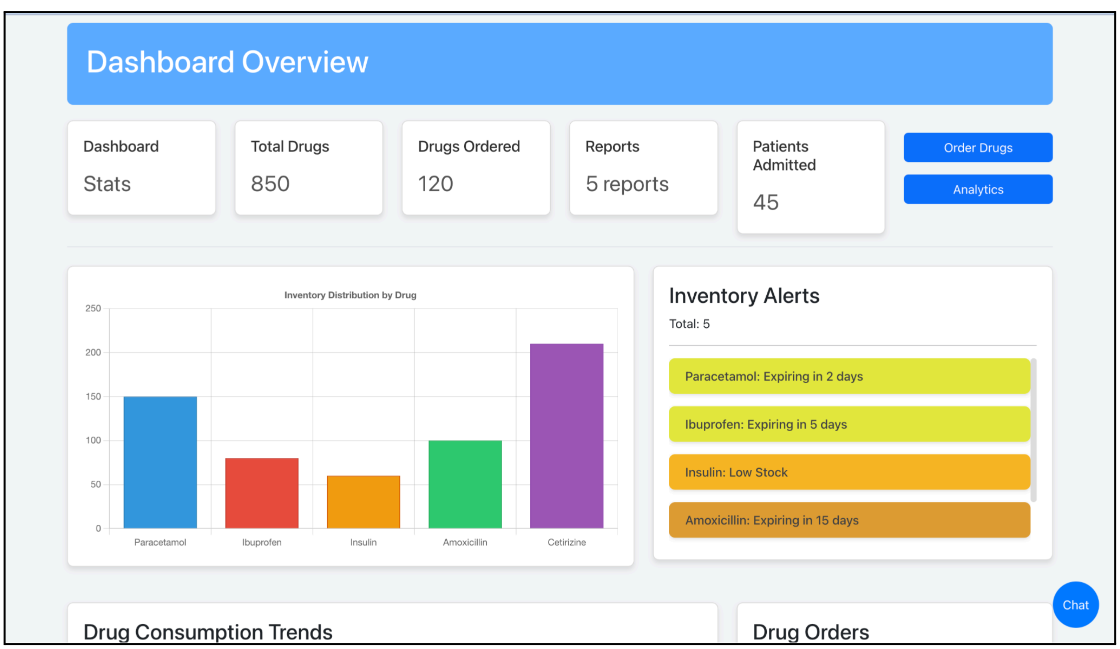

Fig. 7: Hospital Dashboard Overview

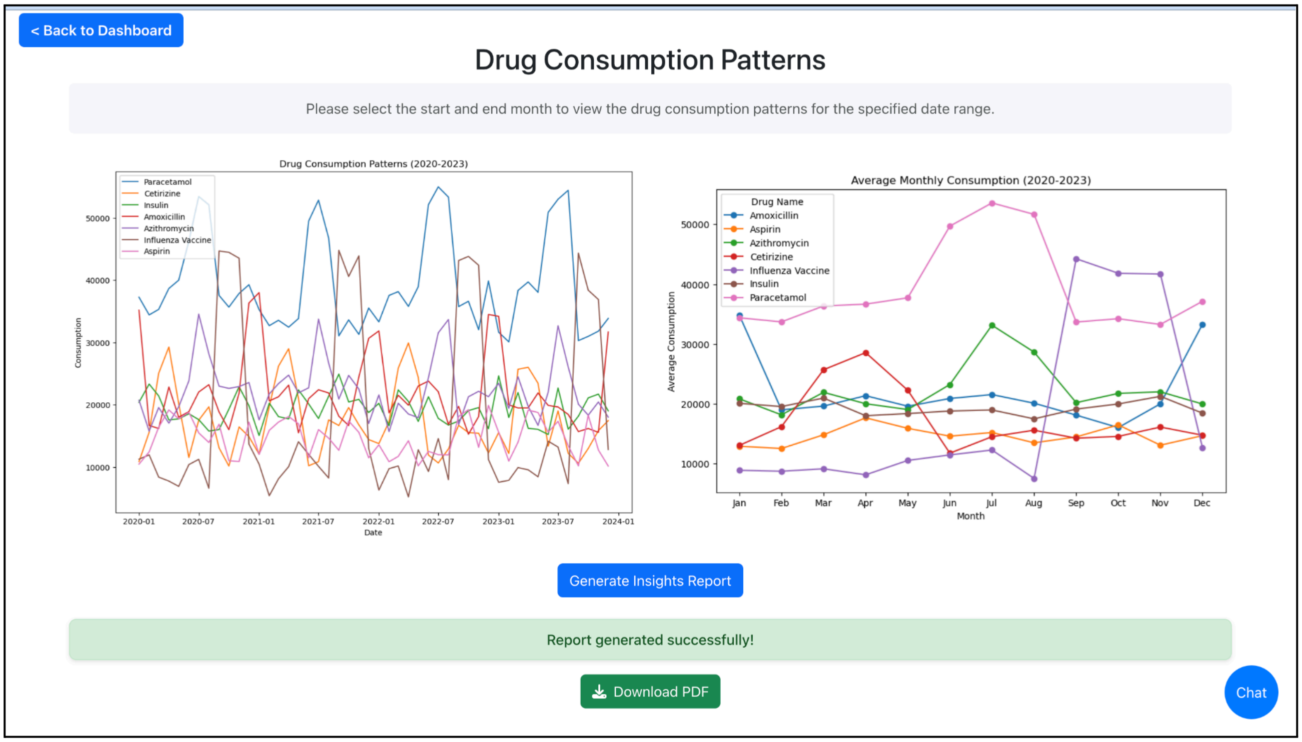

Fig. 8: Monitoring average monthly drug consumption patterns and Report Generation for the same.

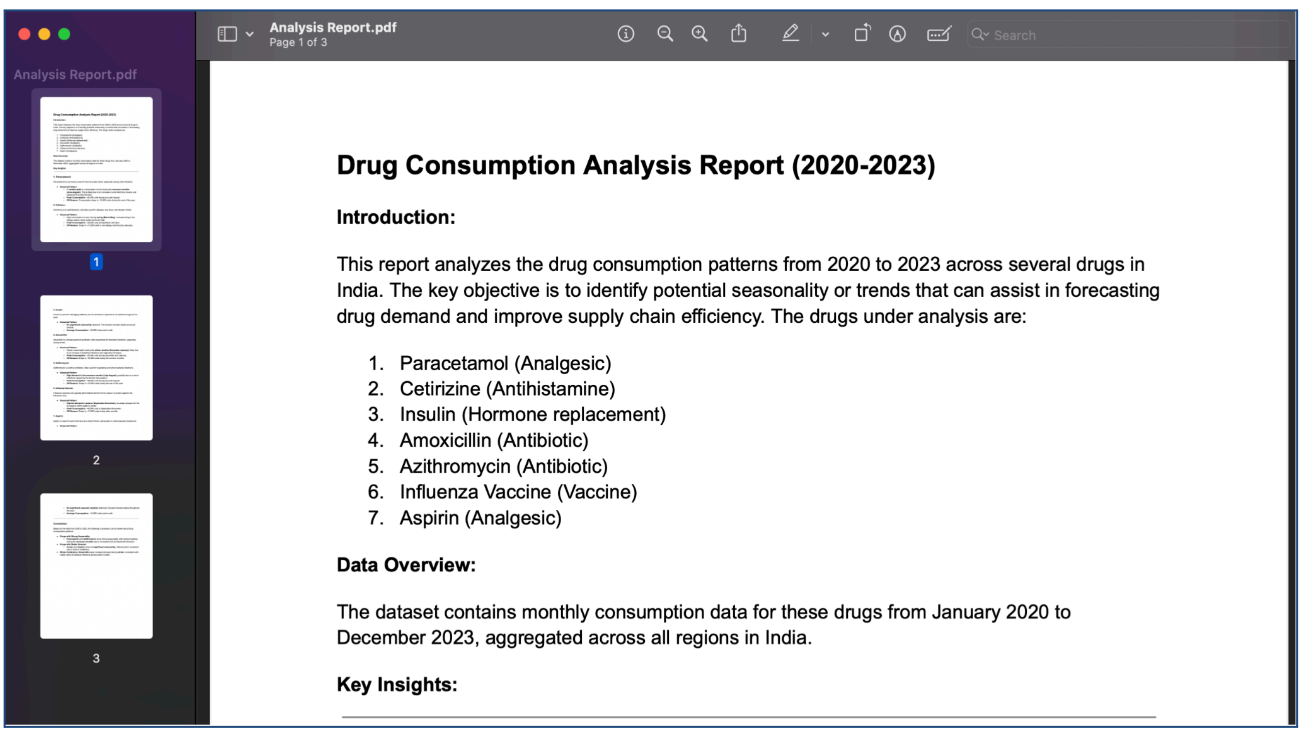

Fig. 9: Report Generation

Chapter V: Proposed Results and Discussions

5.1 Determination of efficiency

1. Inventory Turnover Ratio:

- This key performance indicator(KPI) helps measure how effectively the system manages drug inventory by tracking how many times the inventory is sold and replaced over a period. A higher ratio suggests efficient inventory management.
- The Inventory Turnover Ratio is calculated by dividing the Cost of Goods Sold by the Average Inventory

2. Order Fulfillment Time:

- This assesses how quickly the system processes and delivers drug orders. Faster order fulfillment times indicate improved efficiency in handling and shipping drugs through the supply chain.

3. Stockout Frequency:

- Measures how often a product is unavailable when ordered. A decrease in stockouts can indicate efficient inventory management and predictive analytics performance.

4. Counterfeit Drug Detection Rate:

- The system's ability to identify and block counterfeit drugs from entering the supply chain is a critical efficiency measure, ensuring that only genuine products reach healthcare providers.

5. Automated Reordering Efficiency:

- Evaluating how well the system's AI-powered reordering mechanism works by reducing manual effort and minimizing delays in stock replenishment.

6. Cost Savings:

- A comparative analysis of operational costs before and after implementing the system can reveal efficiency improvements in terms of reduced wastage, minimized errors, and lower operational costs.

7. Shipment Tracking Accuracy:

- Real-time tracking enabled by RFID and GPS can be measured for its accuracy and ability to monitor the exact location of drugs throughout the supply chain, minimizing delays and losses.

5.2 Determination of accuracy

1. Demand Forecast Accuracy

- To measure how close the system's AI/ML-driven predictions (e.g., using SVM) are to actual demand. It helps ensure that inventory levels are optimized, reducing both stockouts and overstocking.

2. Order Accuracy Rate

- The percentage of orders that are delivered correctly (right product, quantity, and condition). Additionally, it ensures that shipments align with hospital orders, preventing delivery errors that can lead to disruptions in drug availability.

3. Shipment Traceability Accuracy

- The accuracy of real-time tracking (via RFID and GPS) in identifying the correct location and status of drug shipments. This helps to ensure reliability in the distribution process, reducing the risk of lost or delayed shipments.

4. Expiry Management Accuracy

- Calculating the percentage of drugs correctly flagged for expiration based on the AI/ML-based expiry management system.

5. Counterfeit Detection Accuracy

- The ability of the system to detect counterfeit drugs using blockchain-based verification to ensure that only genuine drugs enter the healthcare system
- Detection Accuracy is calculated by dividing the sum of True Positives and True Negatives by the Total Cases, showing the proportion of all correctly identified cases among all cases examined in the system.

6. Data Integrity Accuracy

- Measures the accuracy and immutability of data recorded in the blockchain. Since blockchain ensures tamper-proof records, the data should always match the actual events and maintain transparency and trust among stakeholders by ensuring that no unauthorized modifications are made to transaction data.

7. Predictive Maintenance Accuracy

- Accuracy of predictions related to potential supply chain disruptions or equipment failures based on AI/ML models and ensures that the system can proactively handle issues, minimizing downtime and ensuring continuous operation.

5.3 Reports on sensitivity analysis

1. Demand Forecast Sensitivity Analysis

- Assess how changes in demand affect the system's accuracy in forecasting drug inventory needs and simulate different levels of demand fluctuation (e.g., ±10%, ±20%) and observe changes in forecast accuracy.

2. Predictive Maintenance Sensitivity Analysis

- Evaluation on how changes in system wear or external disruptions affect the accuracy of predictive maintenance.
- Simulate varying levels of supply chain disruption (e.g., 5%, 15% equipment failure) and measure the accuracy of anomaly detection.

3. Shipment Traceability Sensitivity Analysis

- Examine how shipment delays and disruptions affect traceability accuracy and simulate GPS/RFID tracking failures (e.g., signal loss, delays) and measure the decline in shipment traceability accuracy.

4. Expiry Sensitivity Analysis

- Test the sensitivity of the expiry management system to incorrect shelf-life data and simulate errors in expiration data entry and observe changes in system performance.

5. Counterfeit Detection Sensitivity Analysis

- Analyze how changes in counterfeit drug volume impact the system's detection accuracy and replicate varying percentages of counterfeit drugs entering the system (e.g., 5%, 15%) and assess the detection rate.

Chapter VI: Plan Of Action For the Next Semester

6.1 Work done till date

1. Identification of Challenges:

- Outlined the primary issues in the pharmaceutical supply chain, such as stock shortages, wastage, and counterfeit drugs.

2. Blockchain Integration:

- Smart contracts have been developed to automate processes like drug order placement, shipment preparation, and delivery verification.
- Cryptographically secure barcodes have been integrated for tracking and verifying the authenticity of drugs.

3. UI and backend::

- The frontend has been built using **HTML, CSS, JavaScript**, and **React**.
- Backend development using **Node.js** and **Solidity** smart contracts on the **Ethereum blockchain** is complete.
- Integration of **Web3.js** for blockchain transactions has been done.

4. AI/ML Integration:

- **AI models** for predictive demand forecasting have been implemented to optimize inventory levels.
- Initial **data analysis and AI/ML integration** for inventory management have been completed.

5. Dashboard Design:

- **Custom dashboards** for stakeholders, displaying real-time metrics like inventory levels, shipment statuses, and alerts, have been developed.
- Data visualization tools using **Charts.js** for interactive reports are in place.

6.2 Plan of action for project II

1. Enhanced GPS Capabilities for Order Tracking

- Focus on improving real-time tracking precision by integrating GPS with predictive analytics. This would optimize delivery schedules and ensure better coordination in the supply chain.

2. RFID-Based Authentication Systems

- Incorporate advanced RFID technology for secure, contactless authentication, facilitating real-time inventory checks and enhancing supply chain transparency.

3. Blockchain-Secured Storage Solutions

- Explore the use of blockchain-secured cloud or decentralized storage systems to ensure secure, scalable, and accessible data management across the supply chain.

4. Integration of SAP with Blockchain

- Investigate integrating SAP enterprise resource planning (ERP) systems with blockchain for secure, traceable transactions, improving transparency and efficiency in financial and supply chain operations.

5. Automated Compliance Reporting

- Leverage AI and blockchain technologies to automate compliance reporting, ensuring real-time adherence to evolving regulatory requirements within the pharmaceutical industry.

6. Incorporation of Big Data Analytics

- Apply advanced data mining techniques and AI algorithms to analyze and visualize large datasets, providing predictive insights to enhance decision-making across the drug supply chain.

7. Completion and Publication of Research

- Refine the research to align with the latest industry standards and target high-impact journals for publication, ensuring that the findings reach relevant stakeholders in the supply chain and blockchain sectors.

Chapter VII: Conclusion

The blockchain-based drug inventory and supply chain tracking system has the potential to transform the pharmaceutical industry by addressing several critical challenges. By integrating smart contracts, AI-driven analytics, and a decentralized ledger, this system can ensure unparalleled transparency, streamline operations, and significantly reduce the risks of fraud and counterfeit drugs. Smart contracts automate key processes, ensuring that drug shipments follow predefined protocols, reducing manual errors, and increasing efficiency. AI-driven analytics provide real-time insights into supply chain performance, enabling proactive decision-making for better inventory management and drug distribution.

One of the system's primary benefits is its ability to enhance patient outcomes by ensuring the accurate and timely delivery of medications. With improved traceability from manufacturer to patient, healthcare providers can have greater confidence in the authenticity and safety of the drugs administered. Moreover, the decentralized nature of blockchain ensures that all participants, including manufacturers, distributors, and healthcare providers, have access to a tamper-proof, immutable record of transactions, enhancing data integrity and reducing opportunities for fraud. Despite these advantages, there are challenges that must be addressed for widespread implementation. User adoption remains a hurdle, as stakeholders across the supply chain may be hesitant to adopt new technologies. Additionally, blockchain scalability is a concern, as the system needs to handle large volumes of data and transactions efficiently without compromising performance.

Future work will focus on addressing these challenges by refining the system's scalability and making the technology more user-friendly. There will also be efforts to expand the system's capabilities, allowing it to adapt to various healthcare environments and comply with different regulatory frameworks, ensuring it can be effectively deployed on a global scale.

Chapter VIII: References

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Chapter IX: Appendix

9.1 List Of Figures

9.2 Paper Publications

a. **Draft of the paper / Paper Published**

b. **Plagiarism report of the paper**

c. **Xerox of project review sheet**

(PFA a,b,c after this report)