A Project report on

A Blockchain Based Approach for Drug Traceability in Healthcare Supply Chain

A Dissertation submitted to JNTU Hyderabad in partial fulfillment of the academic requirements for the award of the degree.

Bachelor of Technology

in

Computer Science and Engineering

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CERTIFICATE

This is to certify that the Major Project Phase-1 report entitled **"A Blockchain Based Approach for Drug Traceability in Healthcare Supply Chain"** being submitted by A.Sowmya (19H51A0501), B.Greeshma Reddy (19H51A0504), Shabana Khan (19H51A0524) in partial fulfillment for the award of **Bachelor of Technology in Computer Science and Engineering** is a record of bonafide work carried out his/her under my guidance and supervision.

The results embodies in this project report have not been submitted to any other University or Institute for the award of any Degree.

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ABSTRACT

Healthcare supply chains are complex structures spanning across multiple organizational and geographical boundaries, providing critical backbone to services vital for everyday life. The inherent complexity of such systems can introduce impurities including inaccurate information, lack of transparency, and limited data provenance. Counterfeit drugs are one consequence of such limitations within existing supply chains which not only has serious adverse impact on human health but also causes severe economic loss to the healthcare industry. Therein, an end-to-end product tracking system across the pharmaceutical supply chain is paramount to ensuring product safety and eliminating counterfeits.

CHAPTER 1
INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 Problem Statement

Healthcare supply chain is a complex network of several independent entities that include raw material suppliers, manufacturer, distributor, pharmacies, hospitals, and patients. Tracking supplies through this network is non-trivial due to several factors including lack of information, centralized control and competing behavior among stakeholders. Such complexity not only results in in-efficiencies such as those highlighted through COVID-19 pandemic but can also aggravate the challenge of mitigating against counterfeit drugs as these can easily permeate the healthcare supply chain.

1.2 Research Objective

According to the Health Research Funding Organization, up to 30% of the drugs sold in developing countries are counterfeit. Further, a recent study by World Health Organization (WHO) indicated counterfeit drugs as one of the major causes of deaths in developing countries, and in most cases the victims are children. In addition to the adverse impact on human lives, counterfeit drugs also cause significant economic loss to the pharmaceutical industry. In this respect, the annual economic loss to the US pharmaceutical industry due to counterfeit medicine is estimated around $200 billion.

1.3 Project Scope and Limitations

The inherent complexity of healthcare supply systems can introduce impurities including inaccurate information, lack of transparency and limited data provenance.

- To achieve the traceability to mitigate against counterfeit drugs is needed within the pharmaceutical industry.
- We propose a blockchain-based solution for the pharmaceutical supply chain that provides security, traceability, immutability, and accessibility of data provenance for pharmaceutical drugs.

The limitations are as follows

- Immutability: Block chains are immutable where any information appended to the ledger cannot be altered or removed.
- Data Privacy: In healthcare supply chains, patients might refuse to have their data stored permanently on the block chain and they can legally sue the healthcare center.
- Scalability: Block chain requires individual nodes to process every transaction on the entire network which provides security and verifiability to the system, but it limits scalability.
- Interoperability: Block chain networks other than Ethereum work in their own unique way which leads to interoperability issues where the different block chains are not able to communicate with each other.
- Efficiency: The efficiency of the block chain solution is highly dependent on the coding of the smart contract and the consensus algorithm used to verify and confirm a transaction.

CHAPTER 2
BACKGROUND WORK

CHAPTER 2

BACKGROUND WORK

2.1. Smart Track

2.1.1. Introduction

Smart-Track is one of the non-blockchain based solution. The end users (patients) can authentically verify the drug by scanning the GS1 (Global Standards1) barcode using smartphone application.

2.1.2. Merits, Demerits and Challenges

- **Merits**
  - Easy to use.
- **Demerits**
  - Smart Track is a centralized system.
  - The recovery from the damages i.e., resilience is extremely low since it is a centralized system.
  - The overall accuracy, completeness, and consistency of data is very less.
  - Since it is a centralized system, the data security is low.
- **Challenges**
  - As smart track is a centralized system, the third person can easily modify the data.

2.1.3. Implementation of Smart Track

Smart Track utilizes GS1 standards barcodes containing unique serialized product identifier, Lot production and expiration dates. The information contained in the GS1 barcode is captured across various supply chain processes and used to maintain a continuous log of ownership transfers. As each stakeholder records the possession of the product, an end user (patient) can verify authenticity through central data repository maintained as Global Data Synchronization Network (GDSN) by using a smartphone app. In the downstream supply chain at the warehouse, pharmacy and hospital units can scan the barcode to verify the product and its characteristics.

2.2. A Novel Medical Block chain Model for Drug Supply Chain Integrity Management in a Smart Hospital.

2.2.1. Introduction

In the current era, every human being has the right to good health facilities. The emergence of an increasing number of diseases on a daily basis has also introduced new drugs into the market with different new labels. These drugs help the patient to get instant relief from pain, but despite the advantages, these drugs also have disadvantages. These drugs are manufactured by different pharmaceutical companies, and the authenticity of these organizations is unknown. According to the World Health Organization (WHO), tens of thousands of deaths occur in developing countries due to fake drugs, and many of the victims are children. According to statistics, the annual business loss of US pharmaceutical industries is approximately $200 billion due to drug counterfeiting. Counterfeiting is not the main reason itself; rather, as compared to traditional drugs, these counterfeit drugs produce different side effects to human health. These drugs may not help patients at all: Instead of curing the patient, they affect their health, and the side effects are even more dangerous to a person's antibiotic resistance cells.

2.2.2. Merits, Demerits and Challenges

- **Merits**
  - It is a framework for permissioned networks, where all participants have known identities.
  - It is built on a modular architecture that separates transaction processing into three phases: distributed logic processing and agreement ("chain code"), transaction ordering, and transaction validation and commitment.
  - It delivers high scalability and fast transactions

- **Demerits**
  - It does not have a proper smart contract development.
  - Network configuration, setup, deployment complexities are higher.

- **Challenges**
    - It only dealt with the drug suuply chain from doctor to patient, but no proper traceability was given.
    - As it is private permissioned block chain, one should create a subnet to know the transactions between other peers in the supply chain.
    - Fabric has insufficient technological understanding, lack of proven use examples, an inadequate talent pool, or a shortage of IT skills.

2.2.3. Implementation of A Novel Medical Block chain Model for Drug Supply Chain Integrity Management in a Smart Hospital

The developed system contains reliable nodes which are responsible for executing a consensus protocol for the purpose of distributed ledger consistency. Initially, the doctor examines the patient and defines a therapy, drug dose, and other advice in the form of a computerized prescription. Then, the computerized prescription is sent to pharmacy personnel who analyze the authenticity of the prescription and request the pharmacist to prepare the drug cart. The pharmacist then sends the drug cart to the pharmacy personnel for cross-verification with the computerized prescription. The prepared drug cart along with the computerized prescription is sent to the head nurse, who verifies and updates the drug inventory of the ward and requests the nurse to start the patient therapy procedure. Finally, the nurse administers the therapy to the patient in accordance with the doctor prescription.

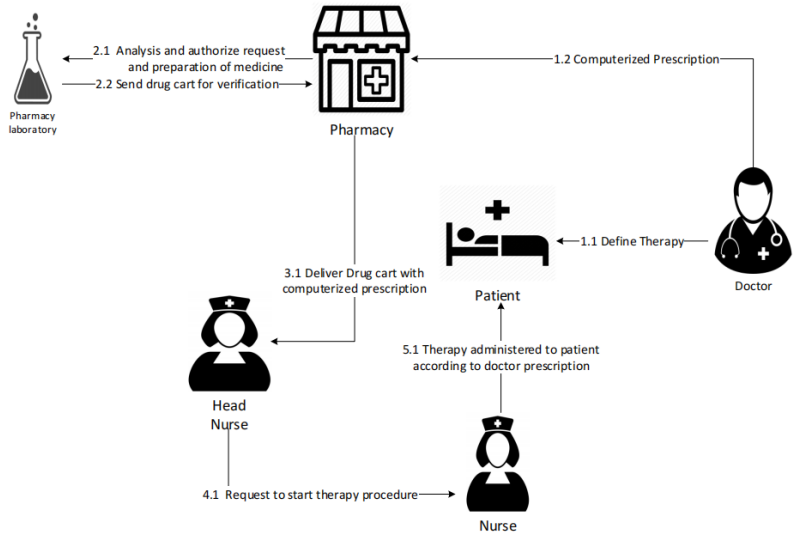

Figure 1: Structure of the proposed drug supply chain management

The developed application is based on a user service framework that uses a smart contract and distributed ledger as middleware. In the proposed system, the transaction proposal is sent by the end user (i.e., doctor, nurse, pharmacist, and patient) through the application to call backend services like medical prescription, profile management, appointment, EDR(electronic drug record), data sharing, pharmacy management, etc., provided by the proposed blockchain network. The blockchain transaction has complete CRUD (create, read, update, and delete) operations that transform the ongoing data between the connected nodes. However, in cases of private and secure transactions, we introduce the subnetwork concept to distinguish the entire network into a separate private network. The main purpose of this private network is to share confidential data directly with the concerned department without exposing them to other departments. The proposed drug delivery system allows each department to create their own subnetworks for the purpose of secure data sharing.

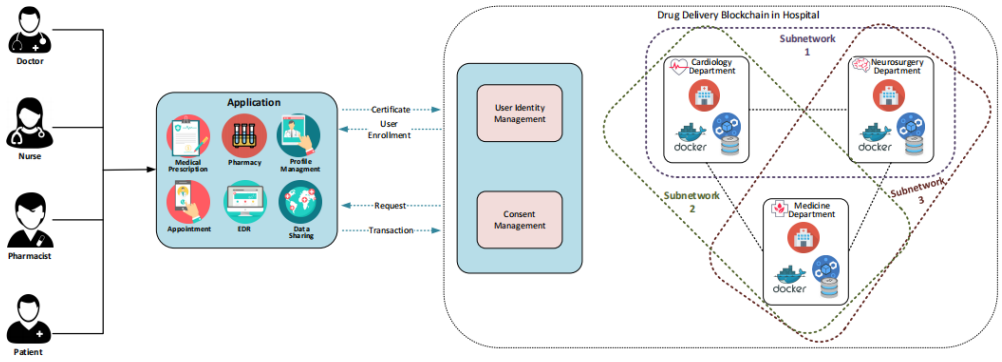

Figure 2: System architecture of the drug supply chain management

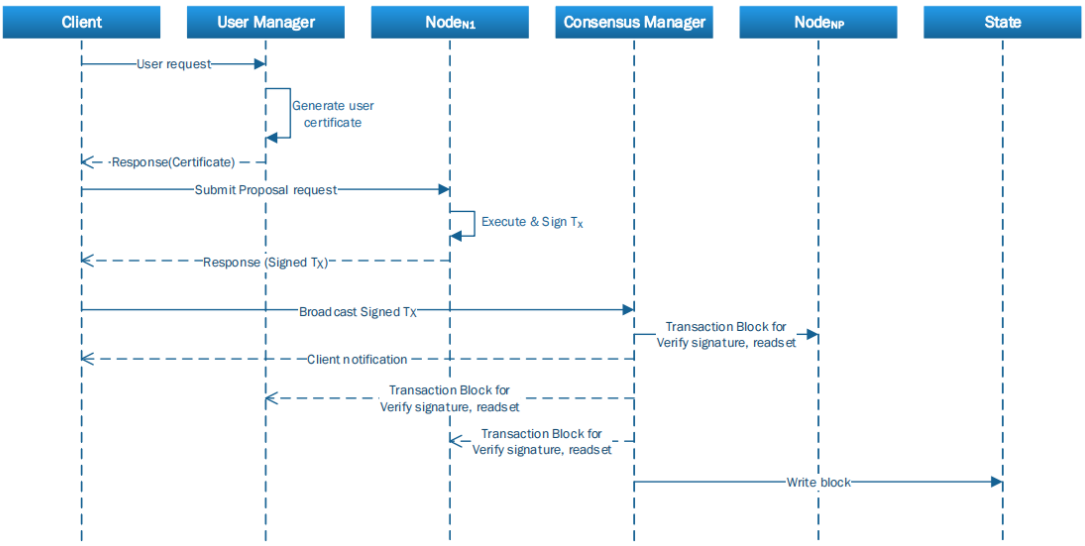

Figure 3 : Transaction flow in the proposed drug supply chain management in a medical blockchain platform.

2.3. Drugledger: A Practical Blockchain System for Drug Traceability and Regulation

2.3.1. Introduction:

Drugledger is a system for drug traceability and regulation that integrates blockchain with drug supply chain. The cyberphysical characteristic should be considered when designing such a system. That is, there are two different and asynchronous flows of drugs that should be taken into account when designing Drugledger: physical flow of real drugs along the drug supply chain, and corresponding information flow that goes through the Drugledger network in the form of blockchain transactions. Drugledger reconstructs the service architecture by separating the service provider into three independent parts, namely, certificate service provider (CSP), query service provider (QSP), and anti-attack service provider (ASP)

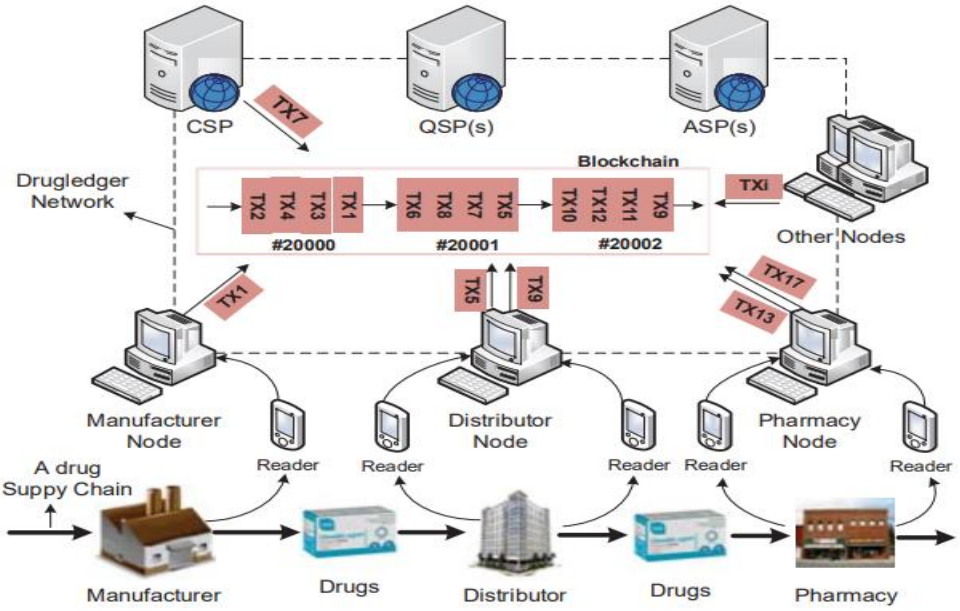

Figure 4: Drugledger service architecture and basic workflow

2.3.2. Merits, Demerits, Challenges

- **Merits**
  - Guaranteeing the authenticity and privacy of traceability data
  - Expiration date of drugs is utilized to prune blockchain storage, achieving a finally stable and acceptable storage.

- **Demerits:**
  - Concerns with the use of UTXO data structure with respect to its weakness in programmability.
  - It requires high storage cost.
  - Low state space utilization.

- **Challenges:**
  - The problem of continuous increasing storage has been a general bottleneck of blockchain system, for which Ethereum state tree pruning have been proposed. These approaches, however, still cannot stop the increasing storage.

2.3.3. Implementation of Drugledger: A Practical Blockchain System for Drug Traceability and Regulation

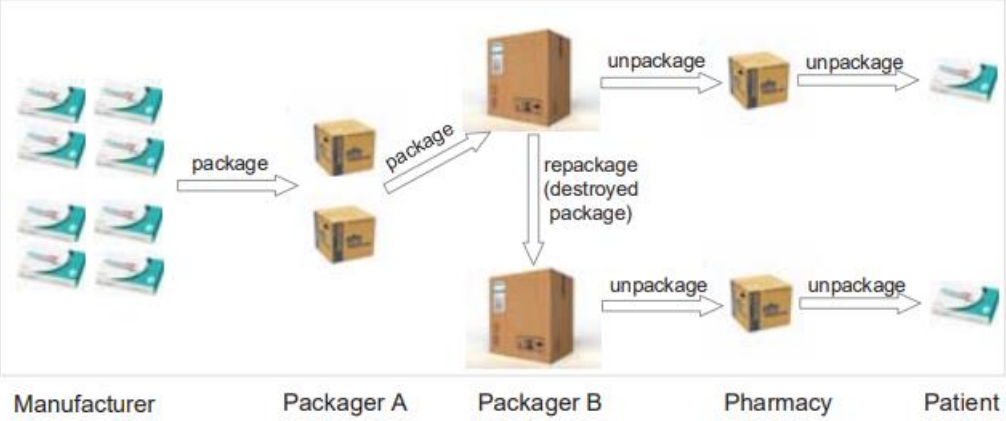

Figure 5: Package, repackage, and unpackage in drug supply chain.

In Drugledger, mechanisms of package, repackage and unpackage are proposed to keep the UTXO-based basic workflow still effective. The basic idea is to realize processes of package, repackage and unpackage as the inherent Drugledger transactions which transfer drugs to the current stakeholder itself (which we call package transaction, repackage transaction and unpackage transaction). After that, the basic UTXO workflow discussed in subsection B can still function as before. The relations between different metadata of various level packages are recorded in the Drugledger blockchain, so that we could still keep track or trace of the whole drug supply chain.

The consensus module is implemented temporarily with algorithms from Algorand cryptocurrency where it limits the participation of final byzantine consensus process (i.e. BA) to a small committee selected by cryptographic sortition and thus improves its transaction throughoutput. Users in Algorand are weighted by their balance, whereas Drugledger weights its user based on the number of valid transactions in the past. This is reasonable in the sense that stations of large companies process more pharmaceutical transactions regularly, take more risks, and thus should share more reputation in proposing a block.

CHAPTER 3
RESULTS AND DISCUSSION

CHAPTER 3

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3.1. Comparison of Existing Solutions

	Smart track	Data matrix tracking system
Decentralized	No	No
Resilience	No	No
Integrity	No	No
Tracking & Tracing	Yes	Yes
Security	No	No

Table 1 :Comparison between the non-blockchain solutions

	Huang et al	Faisal et al.
Blockchain platform	Bitcoin	Hyperledger-Fabric
Mode of Operation	Public	Private
Off-Chain Data Storage	No	No
Programmable Module	None	Docker Container

Table 2 :Comparison between the blockchain based solutions

3.2. Data Collection and Performance metrics

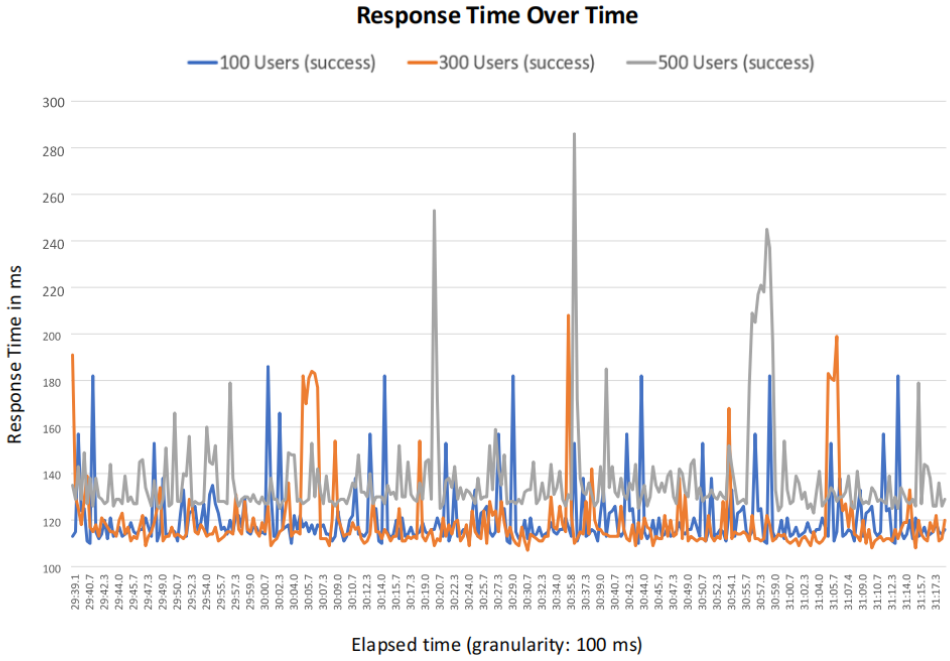

Figure 6 : Response time for different simultaneous requests

It provides a comparison between three different user groups in order to investigate the response time of the proposed system. We ran the simulation for a time period of 100 ms. In general, the response time increases as the number of users increase querying the system at a same time. The three categories of user groups are 100 users at first round, 300 users at second round, and in the end, we evaluated the performance by increasing users to 500.

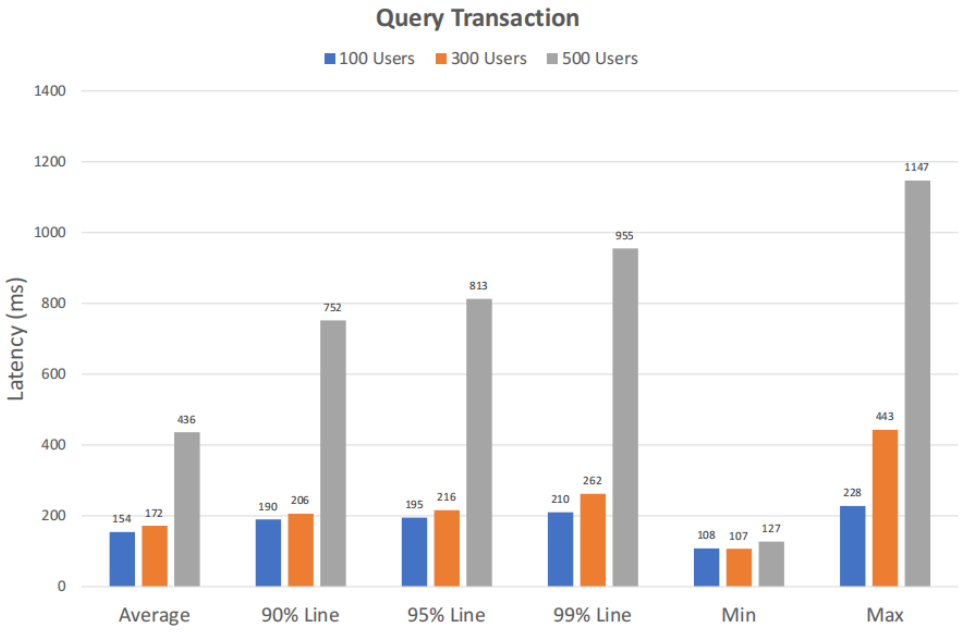

Figure 7: Latency in query transaction (Get Request)

It describes the average, min, max, and percentile latency to execute the invoke process and query function of the proposed system. We calculated the latency of the proposed blockchain system by querying the transaction with three different user-groups. As illustrated in Figure, the user-group with 100 users has an average latency of 154 ms. Similarly, in the case of a group with 300 users, the average latency is 172, and with 500 users, the average latency is 436.

CHAPTER 4
CONCLUSION

CHAPTER 4

CONCLUSION

So to overcome the gaps in the existing solutions and challenge of drug traceability within pharmaceutical supply chains highlighting its significance especially to protect against counterfeit drugs is needed. For that we thought of developing a block chain-based solution for the pharmaceutical supply chain to track and trace drugs in a decentralized manner.

CHAPTER 5
REFERENCES

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REFERENCES

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