Proposed Framework for Dealing COVID-19 Pandemic Using Blockchain Technology

Mansi Gupta[1], Vimal Kumar[1], Vikash Yadav[2]*, Rajesh Kumar Singh[1] and Mohd Sadim[3]

[1]Computer Science and Engineering Department, Meerut Institute of Engineering and Technology, Meerut, India, 250 005

[2]Computer Science and Engineering Department, ABES Engineering College, Ghaziabad, India, 201 009

[3]Computer Science and Engineering Department, Meerut Institute of Technology, Meerut, India, 250 103

The production and distribution of COVID-19 testing kits is an urgent and increasingly worldwide requirement, due to the ongoing pandemic. The accuracy of the kit is critically important and to save the world from the faulty kit becomes an issue. The kit before use has to be approved by an authorized medical research agency like US-FDA, ICMR, etc. In this paper, we proposed a framework that ensures that the testing kit is validated by various measures and gives the history of the supply chain of the testing kit. The parties that are used in the supply chain are Notary, Manufacturer, and Validating Party. A Consumer also plays an important role and can punch the batch number to check whether the kit is approved or not. The framework is developed using R3 Corda, a permissioned distributed ledger technology. A permissioned blockchain is used for data privacy and security so that only trusted parties can leave or join the system.

Keywords: Corona virus, Decentralization, HealthCare Industry, R3 Corda, Supply Chain Management,

Introduction

In Nov'2019, Corona virus was originated from Wuhan, China. It is caused by the corona virus called SARS-Cov-2 and was announced as a world epidemic by the World Health Organization (WHO) on 11'March'2020. COVID-19 causes several deaths and many people battled with this deadly virus and recovered. Till 30'September'2020, 33,844,178 cases have been discovered, 25,148,403 are recovered and 1,012,659 are died due to Corona virus. To contend with this pandemic various strategies have been followed by testing, house arrest, or a creating vaccine. COVID-19 testing plays an important role to detect or discover undiscovered cases by various testing methodologies like Antigen, RT-PCR, Serology, etc. The supply chain management (SCM) of these kits is a crucial and necessary step to get an assurance of an accurate kit which can be described in the scope of how to deal with the COVID-19 pandemic using block chain technology.[1] SCM is the process of tracking and managing each process involved from raw to a finished product or from supplier to consumer. For the prevention of faulty kits, there is a requirement for an effective supply chain management system, and the best accessible answer for developing an ideal SCM system is Blockchain technology. Blockchain[2] is a decentralized technology which was developed by Satoshi Nakamoto in 2009, in which various nodes or computer share a common ledger that stores immutable records or set of transactions which are secured by a cryptographic function or highly computational mathematical problems. The function used is of the form[3]:-

$$H: K \times M \to \{0,1\}^n \qquad \ldots (1)$$

Where H denotes hash and n denotes the number of bits returns by the function. Its first implementation was Bitcoin (crypto currency) in 2014. It overcomes various transaction issues like the double-spending problem, but it is not only limited to the financial sector as blockchain grabs attention in various non-financial sectors like Education, Healthcare, Real Estate, etc., and gets exploring day by day. This paper tells how blockchain technology works, how this can be implemented to deal with the COVID-19 pandemic, how testing kits SCM can be implemented to check whether the kit is validated by an authorized party or not by using a permissioned blockchain platform called R3 Corda. The rest of the paper is

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*Author for Correspondence
E-mail: vikas.yadav.cs@gmail.com

divided into various sections. Section 2 discusses the existing framework or work of other researchers in the field of healthcare and COVID-19. Section 3 describes the motivation behind the proposed system and the requirement for Blockchain. Section 4 describes the reason for using R3 Corda and compares public and private blockchain. Section 5 describes the implementation and participating parties. Section 6 consists of future scope, a conclusion with the references at the end.

Motivation and Contribution

To give a protected and productive COVID-19 Testing kit gracefully conspire, a comparable sort of system utilized in the Pharmaceutical supply chain or other medical services related territories have been concocted, for example, MedRec, ModelChain, MediLedger, etc. To build such a framework, numerous analysts have utilized various platforms, for example, permissioned Ethereum, Hyperledger Fabric to give transparency. The above platforms utilized are not as much secured and incapable to give protection when contrasted with R3 Corda. Corda is a private blockchain platform that supports Java/Kotlin and for the most part, has an application in the money related area. In the current Covid-19 testing kit supply chain model, the method isn't transparent to the client, and there can be an opportunity that physically kept up records of kits approval can be lost. The producer sends the kit to an approved party for approval; the approving party essentially stores the records as tables. There can be the opportunity that buyers can't get genuine and right information identified with kit approval. This gave the inspiration to build a blockchain platform for kit Supply Chain Management. The commitments in the proposed COVID-19 testing unit SCM structure are as per the following:

a) Our system gives high security regarding that no unapproved party can be added to the chain and high transparency is additionally given.

b) The information that store on the chain is permanent and made sure about by profoundly registered cryptographic calculations. Every exchange is approved by a Notary so that any off-base or inaccurate exchange can't be added to the chain.

c) The mistake can be appeared to the client by punching the Batch Number if the kit isn't approved.

Along these lines, our system is more proficient than the current methodology utilized in testing kit supply chain management. To the best of the creators' information and conviction, this structure can be executed in true applications and can supplant the current methodology.

Related Work

In the survey, not many endeavors have been made in the supply chain in the healthcare industry or providing a solution to deal with COVID-19 using blockchain. Ijazul Haq[4] proposes a use case in the field of pharmaceutical industry using blockchain technology to prevent counterfeit drugs and explains how traceability of drug supply can be gained. In the paper, he uses permissioned blockchain and suggests the system with an example that shows how different parties like Nurse, Doctor, and Patient can use the system. MedRec[5], a white paper published that introduces a system for study purpose in future to researchers and provide storage of secret medical data. It presents a system for saving patient's data and effectively accesses that data by fusing blockchain security. Sandip Jangir[6] proposes a novel framework using distributed ledger and smart contracts for pharmaceutical SCM. The system is built using the Ethereum platform that achieves privacy, demand-supply management, and real-time tracking of drugs. Proper analysis and experimental results have been taken in terms of User Privacy, Immutability, Data transparency, No single point of failure, High availability, Non-repudiation, and real-time tracking of drugs for proof of concept of the introduced system. Peng Zhang[7] proposes a framework or decentralized application (Dapp) called FHIRChain for sharing clinical data scalably and securely using blockchain. This work can further be extended to other issues related to healthcare interoperability. William J. Gordon[8] discusses health data interoperability issues and why there is a shift to patient-driven interoperability from institution-driven interoperability. In the paper, he describes benefits, various limitations, and challenges. Tsung-Ting Kuo[9] proposes a framework called ModelChain that is used to preserve healthcare data using private blockchain networks by integrating Machine Learning into it. He also developed a new proof-of-information algorithm to find the order of blockchain-based online Machine learning. Si Chen[10] proposes a supply chain quality management framework based on blockchain that provides a theoretical basis to intelligently apply management to the system and can be used in a real-world application. Mohamed Torky[11] provides an innovative framework to deal with COVID-19 by detecting unknown COVID-19 patients using

blockchain. The framework is divided into four main components; they are P2P mobile Application, Infection Verifier System, Blockchain Platform, and Mass- Surveillance System.

Purpose

There can be various issues arise while supplying COVID-19 testing kits such as kits can be faulty, not giving accurate results, the defect can be caused at the manufacturer end or between the supply of the testing kit. The kit when manufactured it has to be validated by authorized medical like the Indian Council of Medical Research (ICMR), US-FDA, etc. There can be a chance when unauthorized or fake marks are printed on the testing kit or counterfeiting of the kit can take place. To deal with various issues discussed, the SCM can be implemented using blockchain and the purpose of the proposed system can be pointed as:-

I. **To provide Transparency: -** Customers can track the testing kit throughout the supply chain; from manufacturing to the validation done by the validating party this brings transparency. Customers can punch the unique id associated with the kit into the system and can see if the manufacturer or validating paper is legitimate or not.

II. **To provide Traceability:-**Once the kit is manufactured then it will be registered on the blockchain by the manufacturer in return a unique id or Batch No. will be generated. Using this id the kit will be traced, tracked, and certified at each stage of SCM.

III. **To provide Security:-**Blockchain is one of the ideal secured technology or ledger systems available right now. Once the information on the blockchain is stored cannot be modified or deleted. In the proposed system, we are using a permissioned blockchain which is more secure than a public blockchain, in which only authorized or legitimated users can participate in pushing the data to the chain. The data privacy and security will be achieved by the fact that data will be stored in the encrypted form using a hash algorithm called SHA-256 and nobody can access or break the security system of blockchain unless 51% attack.

Why R3 Corda?

Corda[12] is a decentralized database platform which mainly focuses on the financial domain and supports smart contract. In Corda, the smart contract is a pure function that responsible for accepting or rejecting the transaction. R3 Corda is a private blockchain that restricts users to leave or join, when a node transfer a message to another node then the message is only visible between these two nodes unlike in other platforms in which every node can see the message. There are various platforms available in the market to develop blockchain, and they can be categorizing into four board categories called public blockchain, private blockchain, hybrid blockchain, and consortium blockchain. Ethereum[13] and Bitcoin are some famous public blockchain. Hyperledger Fabric[14] and R3 Corda[15] are some famous private blockchain. Quorum and Hyperledger are some consortium blockchain. Many applications are created using Ethereum & HyperLedger fabric which are widely used but we built our system using R3 Corda because of various reasons such as: Firstly, it is a private blockchain platform and prevents any unnecessary sharing of data. Secondly, in decision making the nodes that are performing transactions can only take part. Lastly, Corda makes its consensus algorithm rather than following developed algorithms. The difference between public blockchain and private blockchain can be shown in the Table 1 given below:-

System Architecture and Parties Involved

Parties Involved

Testing kits play a major role in dealing with the COVID-19 pandemic; as expedite the test sooner we get rid of COVID-19. But for a smooth testing procedure, there should be a proper check on the testing kits to that they are working properly or not giving any false results. Accuracy and efficiency play an important role, and to achieve this testing kit must be validated by an authorized/ trusted party before

Table 1 — Comparison Between Public and Private Blockchain

Parameters	Public Blockchain	Private Blockchain
Access	Open to anyone	Single Organization
Speed	Slower	Faster
Network Architecture	Decentralized	Partially Decentralized
Consensus	Permissionless	Permissioned
Immutability	Complete, Impossible to tampered	Partial, can be tampered
Efficiency	Low	High
Number of Users	Millions	Few Hundreds

use. To ensure this, the supply chain of testing kit should be maintained by using blockchain technology as there can be the chance that the manufacturer can supply the kit directly to the user, or there can be the probability that any fault can occur in between the supply chain. The participating parties in the whole framework are:-

Notary

A notary is a network service by the Corda system that checks whether the transaction or any updation to the chain is valid or not and check for its dependencies. In the dictionary, a notary is a person who is authenticated to do certain legal work, especially to draw up or allot certificates or other legal documents for use in jurisdictions. Notary manages the contract between the manufacturer and validating party, he legitimates the transactions occurring are according to the contract.

Manufacturer

The manufacturer produces a testing kit by considering the terms and conditions prescribed by medical agencies and send the kit to any authorized validating party before supplying it to the consumer. To ensure traceability, all the details of the kit will be maintained on the chain. The details include the Name of Kit, Name of company, Manufacturing Date, Expiry Date, Kit Details. After uploading all the details then a unique UUID i.e. Batch Number will be generated for further reference.

Validating Party

The Validating Party can be any authorized medical research agency like ICMR[16] that has the right to approve the testing kit for further medical use. ICMR follows different rules for each kind of testing kit, but if the kit is US-FDA approved then the kit can be supplied directly. The validating party performs various test reactions, reagents, methodology, and sent the validation report to the manufacturer. If the kit is approved, then only the manufacturer can supply it to the consumer otherwise the manufacturer has to perform corrections that are instructed by the validating party. The validating party has to upload some details for ensuring transparency, which is follows: - Batch Number, approval, comments, Approved By.

After a successful approval kit reaches at consumer end then the consumer will punch the batch number and can see the details which are Batch Number, Manufacturing Date, Expiry Date, kit Details, etc.

Suppose the testing kit is directly supplied by the manufacturer to the consumer without being validated by the validating party then an error will be shown to the consumer by punching the Batch Number to the system.

Software Required

For implementing the above-described framework R3 Corda platform used, and for development of CorDapps, we required some tools that are described below[17]:-

a) *IntelliJ IDEA 2020.1.2:-*

IntelliJ[18] is an Integrated Development Environment (IDE) that supports both Kotlin and Java development. It is available as an Apache 2 Licensed and developed by JetBrains (formerly known as IntelliJ) in January 2001. Corda supports Kotlin plugin version 1.2.71 and IntelliJ Idea versions 2017.x, 2018.x, and 2019.x.

b) *JDK1.8:-*

Corda requires Java Development Kit (JDK) for development, it requires at least version 8u171. JDK includes its private Java Virtual Machine(JVM) resources like Java Runtime Environment(JRE), Interpreter, Compiler, Archiver, Documentation generator that are required for developing Java-based applications.

c) *Postman 7.28.0:-*

Postman[19] is a software development tool that is used for testing Application Programming Interface (APIs) which is started as a side project by Abhinav Asthana. The features of postman can be the Compact Layout, API responses for JSON and HTML, HTTP requests with file support, etc.

Implementation

The system for kit validation containing three nodes, they are Validator, Manufacturer, and Notary these nodes/peer Corda sends the requests to the API in the form of an HTTP request and gets the result accordingly. There are three hosts used in the system they are, Corda Vault, Application Tier, and Corda Float. Corda vault stores the transactions that are taking place. In Corda, the transaction types are defined using JVM code that means byte code execution should be fully deterministic. CorDapps (Corda Distributed Applications) are the applications that run or developed on the Corda platform. In CorDapps, classes are defined in JAR files which are
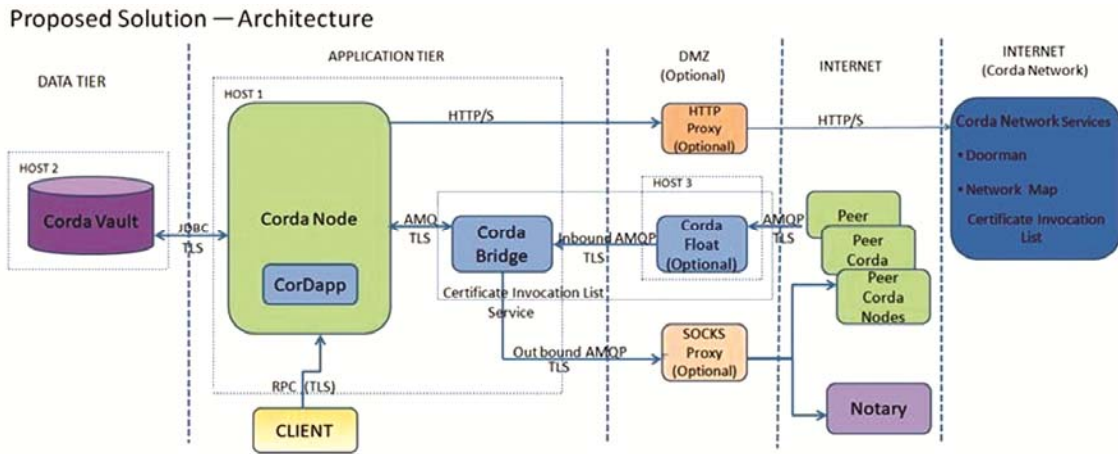
Fig. 1 — System Architecture

programmed in Kotlin and/or Java. The functional aspects of Corda are CorDapps that permit Corda Nodes to achieve agreement on updates to the Vault (DLT ledger/database) for given use cases. Using JDBC, Corda Nodes hold the shared results of CorDapps in a database (vault). The Nodes communicate in a peer-to-peer fashion using AMQP/TLS. The various parties interact with these nodes such as Client applications interact using RPC/TLS and Administrators interact over SSH. Corda Nodes attain an identity certificate via a Doorman service using HTTPS and they learn about other trusted Corda Nodes and their addresses via a Network Map service using HTTPS. Corda Bridge and float uses Corda-firewall.jar. The Bridge catches the inbound messages and sends them to the mutual Artemis line. The Bridge is regularly designed to course through a SOCKS Proxy Server and deliver active messages from the Node to Peers on the Network. The system architecture and workflow of the proposed framework for kit validation can be shown in Fig 1.

Conclusion

In this paper, we proposed a framework for COVID-19 testing kit supply chain management in the field of healthcare using blockchain technology. We pointed out various entities that are involved in SCM and implement this SCM using R3 Corda. We also discussed various tools used and working scenarios. In the future, work can be extended in various ways like by developing solely CorDapp that does not require any third party API to run, replacing unique id to some more secure code or method, adding more intermediate to chain to bring more transparency, adding more options to the system like uploading files, etc. As we all wish that COVID-19 should end soon, that doesn't mean we cannot use this framework, as this framework can be implemented practically in other areas and can be used further.

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