FTEC5520

Applied Blockchain and Cryptocurrencies

Vaccine Management and Authentication Platform Based on Blockchain

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ABSTRACT

Main goal in this project is to design a vaccine management and authentication platform to track each vaccine during the producing process, transportation status and also recognize the authenticity of the vaccines all based on Blockchain.

With the outbreak of the COVID-19 epidemic, the vaccine management system has been considered as an important section in public health management. Researchers and engineers have been dedicated on developing solutions with existing IT systems, together with those newly developed to support COVID-19 vaccine tracking, allow for reliable, rapid data collection. Vaccine safety is closely related to public health and national security. However, issues such as vaccine expiration and vaccine record fraud are still widespread in vaccine supply chains. Therefore, an effective management system for the supervision of vaccine supply chains is urgently required.

As an up-to-date technology, Blockchain technology aims to provide a new method of information management and verification through its unique trust mechanism. This project attempts to design a prototype of a novel, secure, and convenient decentralized, peer-to-peer COVID-19 vaccine management system based on the Hyperledger Fabric Blockchain platform. The system is designed to improve the vaccine traceability and efficiency of the vaccination process, which can be used to solve the problem of vaccine expiration and vaccine record fraud. Meanwhile, this project explores the possibility of implementing digital health pass based on Blockchain.

This report records the process of researching, designing, constructing, and further exploring of the solution.

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1 INTRODUCTION

1. 1 BACKGROUND

In December 2019, the world's first recognized case of COVID-19 was reported in Wuhan, China. Over the past year, the debate about the origin of the virus has never stopped.

Globally, as of 11:47am CEST, 23 April 2021, there have been 144,099,374 confirmed cases of COVID-19, including 3,061,912 deaths, reported to WHO. As of 21 April 2021, a total of 899,936,102 vaccine doses have been administered. [1]

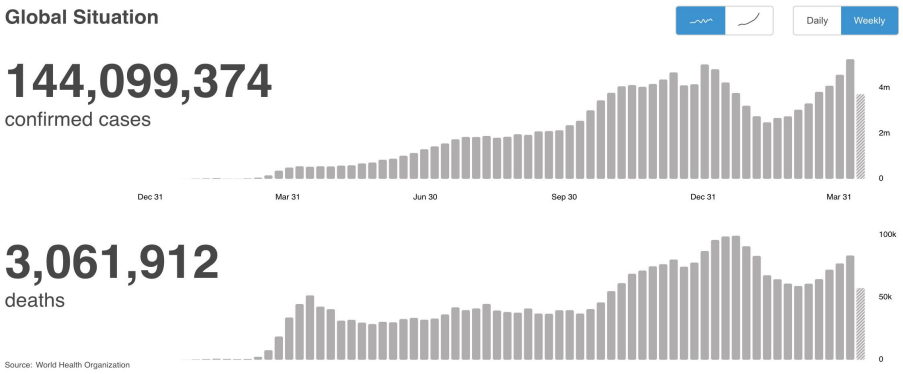

Figure 1: Global Situation of Confirmed cases and deaths (WHO)

The public is more concerned with the development of the coronavirus vaccine and its effectiveness than with tracing its origin. Developing a vaccine of any kind is a difficult process, especially since the disease is contagious and so widespread. People's lives have obviously been a lot of inconvenience due to the COVID-19. Since the COVID-19 vaccine was successfully developed this year, many countries and regions plan to order the COVID-19 vaccine from China and let people receive the vaccine vaccination.

The three vaccine frontrunners are developed by Pfizer/BioNTech, Moderna and Oxford/AstraZeneca. RNA vaccines, as a new approach that is incredibly quick to design, developed by both BioNTech and Moderna. The vaccine developed by Oxford is subtly different as it uses a harmless virus to carry the same genetic material into the body which also make it the easiest of the three to use and to store.

Company	UK Approved	Type	Doses	Storage
Oxford Uni-AstraZeneca	✓	Viral vector (genetically modified virus)	x2	Regular fridge temperature
Pfizer-BioNTech	✓	RNA (part of virus genetic code)	x2	-70C
Moderna	✓	RNA	x2	-20C
Novavax	Pending	Protein-based	x2	Regular fridge temperature
Janssen	Pending	Viral vector	x1	Regular fridge temperature

Figure 2: how the vaccines compare

One of the authors of a phase I and phase II trial of the vaccine, published in the Lancet medical journal in December2020, said a clinical trial involving 144 people and a phase II trial involving 600 people showed the vaccine was safe and suitable for emergency vaccination. In early October 2020, the vaccine began phase III clinical testing in Brazil, which at the time had the second highest number of COVID-19 deaths. In Brazil, which has the second-highest number of deaths from the novel coronavirus disease, the death of a volunteer in November led to the suspension of testing, but the cause of death was later found to be unrelated to the vaccine and resumed.

Yin Weidong, Sinovac's chairman, was quoted by China's official Xinhua news agency as saying that when the second production line is completed and put into operation, annual production is expected to exceed 1 billion doses in 2021. Late last year, Sinovac said it could produce 300 million doses of vaccine a year at its new 20, 000-square-metre plant. Approvals for emergency use of Sinovac have gradually increased this year, with Indonesia, Turkey, Brazil and Chile among the first countries to receive shipments of vaccine.

According to the joint prevention and control mechanism of the State Council announced at a press conference held by the National Health Commission on March 28, 2021, as of 12am on March 27, China has reported vaccinating more than 100 million doses of Novel Coronavirus vaccine. [3]

While providing COVID-19 vaccines to many countries, expanding production bases overseas has also become an important step in China's vaccine diplomacy. The

United Arab Emirates will begin production of Sinopharm's inactivated vaccine in April, making it the first country in the Gulf region to have a vaccine capacity. Meanwhile, China has begun offering COVID-19 vaccinations to foreigners in the country.

1.2 MOTIVATION

In USA, according to a Gallup poll, the number of Americans willing to get vaccinated rose to 71% in February. In China, More than 40 million cases of the new coronavirus vaccine have been vaccinated in China, with a coverage rate of 2.9%, while the Chinese vaccine is being continuously promoted to the world. In Europa, Pfizer will supply an additional 200 million doses of the new coronavirus vaccine to the EU from February 17, of which 75 million doses will be available in the second quarter. In the meantime, Moderna will provide an additional 150 million doses of the new coronavirus vaccine to the European Union, which will be delivered this year.

However, how do we, as the general public, possible to know exactly where the COVID-19 vaccine came from, if we want to track where it was produced, how it was transported, what happened to it after it was discarded and so on. [4]

The pharmaceutical cold chain transportation is known as the top of the cold chain industry pyramid. The Novel Coronavirus vaccine, which requires cabin temperatures between -20℃and 8℃for drug shipments, typically needs to be transported and refrigerated at -20℃. For example, U.S. vaccine maker Moderna expects its vaccines to be shipped and stored at -20℃, while Pfizer has revealed that its vaccine developed in partnership with BioNTech has a temperature range of -70℃ to -10℃. The whole process of storage and transportation also needs to be monitored and recorded regularly. Many experts point out that the number of airports with cold chain equipment in the world is relatively small. When the vaccine arrives at the destination airport, there is the problem of maintaining cold chain temperatures. In addition to the challenge of maintaining temperature on the tarmac, the ability to maintain the airport's refrigerated warehouses is also an issue. It can be said that "last mile" transport is the most complex and uncontrollable part of the logistics chain.[5]

1.3 SIGNIFICANCE OF PROBLEM & INNOVATION

Various risks are likely to arise in the lifecycle of a vaccine. About all, in the production period, what matters is unqualified raw materials. The Wall Street Journal reported Pfizer’s vaccine production halved since their early raw materials failed to meet standards [6]. During the transportation and storage section, compared with other fields, the pharmaceutical industry has a more complex supply chain, whose participants include various organizations. and it is critical to control temperature. Some manufacturers have indicated temperatures should be at least as low as below 20 degrees [7]. As for the distribution and vaccination stage, how to distribute vaccinations to the local population in a timely and effective manner is another thorny issue, as Los Angeles Times reported, because of dose misses, upload errors, time delays, and software problems, it was impossible to keep track of exactly how many

doses of the vaccine were available in California [8]. There was even a "wrong injection" incident in Hong Kong.

In the face of these challenges, governments have implemented a series of solutions. In HK, the general public can download both their electronic vaccination record and testing record through the “iAM Smart” mobile app [9]. In the Mainland, the Government has introduced an electronic identity card for vaccines. However, these solutions cannot solve the contradiction between the fragmentation management pattern and the full traceability requirement. It is significant to build a vaccine traceability network based on Blockchain.

The Blockchain-supported vaccine traceability network has three main advantages which are end-to-end traceability, reduced risk, safety, and efficacy assurance. With this network, manufacturers can monitor adverse events and improve recall management. Distributors can be informed in real-time, increasing their ability to respond to supply chain disruptions. Vaccination facilities can improve inventory management and safety monitoring [10]. At last, People can trust the vaccine and actively vaccinate.

1.4 METHODOLOGY & TOOLS

This project consists of an underlying Blockchain framework and a web application. The entire system is deployed on an AWS EC2 cloud server, using other services of AWS as assistances. The specific infrastructures and tools for this project are listed in Table 1.

This project uses Amazon Web Service (AWS) as the main infrastructure provider. An AWS EC2 deployed with Centos 7.7 will be our main server and based on that, we use AWS Managed Blockchain to establish our fundamental nodes on the Blockchain network, AWS Cloud 9 as the integrated development environment (IDE), AWS S3 as our data storage service to share data among team members. In addition to AWS, the built-in database is MySQL, and our web application is published by a JavaScript framework. The key deliverable of the project will be a protocol of a vaccine traceability network based on Blockchain technology, in the form of a web application, deployed on AWS EC2. The core contents, including Chaincodes, front-end elements, and fundamental library of Fabric will be packaged as deliverables, and for detail, please refer to section 2.6.

Infrastructure & Tools used	Function	Version/Type
AWS EC2	Main Server	CentOS 7.7
AWS Cloud 9	IDE	NA
IntelliJ Idea	IDE	NA
AWS S3	Sharing Storage	NA
Hyperledger Fabric	Blockchain Framework	1.4.4
Hyperledger Explorer	Background Explorer	1.0.0 - rc2
MySQL	Database System	NA
Java	Language of Chaincode	NA
JavaScript & HTML	Language of Frontend	NA

Table 1: Infrastructures and Tools

2 MAIN REPORT

2.1 DESIGN PRINCIPALS

2.1.1 BACKGROUND

The medical record needs to be in the hands of the patient. With the occurrence of life events, the patient's medical record data is stored in the electronic systems of various medical institutions. Doing so will make it impossible for patients to access past data easily. Patients cannot manage their medical record data. They cannot ensure the privacy of their medical record data.

The life cycle of vaccines needs to be recorded on the Blockchain throughout the entire process. Vaccines against the new crown and various other epidemics have been widely vaccinated. Still, the management of vaccines often has a considerable information lag, so that multiple vaccines are improperly handled and even faked. Vaccine factories can use the Internet of Things technology to automatically record information on the Blockchain from the beginning of the production of vaccines. The subsequent vaccine life cycle and vaccination status can be read and traced on the Blockchain.

Disease information needs to be transparent and truthful. The public sector cannot know the report of a large number of vaccinators. When there is an emergency public health situation, general management can use the accurate and reliable data of individuals on the Blockchain to manage the environment, avoid overreaction and fine-tune control.

2.1.2 SOLUTION

Use distributed ledger technology to establish a distributed record management system. This system provides patients with identifiable personal management data; doctors write vaccine data and a distributed ledger that records manufacturer information on the entire chain. This system can manage identity verification, confidentiality, accountability, and data sharing, which are essential considerations when handling sensitive information. The system can incentivize medical stakeholders (researchers, public health authorities, etc.) to participate in the network as Blockchain "miners". The system allows them to access aggregated anonymous data as a reward to maintain and protect the network through proof of work.

2.1.2 FUNCTIONALITIES

The vaccine is fully automated and recorded by the IoTs during the production process. The vaccine information is instantly transmitted to the vaccine data chain to reduce the possibility of even human intervention. Vaccine data avoids repeated recording from the beginning, and once recorded, vaccine data cannot tamper. Only the process attributes can be added, thereby enhancing the authenticity of the data.

The entire cold chain management of vaccines can be entered through the Internet of Things data and monitored in the background to ensure that the IoTs equipment related to the transportation and storage of vaccines can automatically warn and

process relevant vaccine data to avoid human tampering. Hospitals and doctors will also write the vaccination process, and it is limited to the increase of vaccine data and does not involve the elimination of vaccines.

A. Vaccine data record

In the end, vaccinated users can safely vaccinate the vaccine itself and further verify their identity through face recognition data. The complete life cycle management of vaccines is carried out on the chain, IoTs devices and medical practitioner's full data entry, and end-users can trace the safety of vaccines on time when faced with vaccines. In the follow-up vaccination management process, it will refine the medical feedback records of the vaccine, and the manufacturers and users will jointly complete the improvement of the vaccine.

B. Doctor writes records

The hospital can independently verify the validity of the vaccine data on the chain and manage the vaccine's use and storage in the hospital.

Doctors can only write the transparency of vaccine data. It cannot be modified by doctors, which can promote the sharing of treatment plans among doctors and keep user data confidential. Vaccine data can be vaccinated and used by doctors after verification on the chain, thereby significantly improving the doctor's practice status. Doctors can get rewards for writing data, and treatment can be handed over to patients for anonymous evaluation, encouraging doctors to participate in treatment compliantly and share authentic and effective treatment plans with patients.

The doctor evaluation system will reshape the credibility of medical institutions and return the evaluation power of public health events to patients instead of external rating agencies, thereby reducing operating costs and improving patient welfare.

C. Personal record management

Distributed ledger technology ensures that user data privacy is entirely in the hands of users after storage.

Users can independently set access permissions to finely control data permissions and develop different access strategies for other people. The doctor can open the write permission, and the user can evaluate whether the doctor's plan and the vaccination situation are satisfactory. The hospital can open anonymous query permissions, and users can get reminders of the vaccination progress from the hospital and feedback on their vaccination response. The user's groups and companies can open up query permissions, and relevant agencies can quickly check the vaccination status and vaccine effectiveness for public management. Simultaneously, the company can even set its own required conditions to perform zero-knowledge proof for inoculation data and other related data of interest to query more data that the company cares about, and users can choose whether to accept or not based on the relevant query content.

Users take the initiative to master data privacy and provide users with social sharing. When users choose close relationships, they can exchange and query their

medical conditions and provide reliable health conditions issued by traditional medical institutions. When users choose to provide their medical data to a third-party organization, the third-party organization can ensure that the user's health records come from a regular medical organization and provide them with prescription drugs to prevent drug abuse. Simultaneously, if a third-party organization wants to know the user's vaccination or other health data, the user can decide whether to sell the data at a price. For example, the amount of data obtained will be proportional to the amount paid.

2.2 COMPARISON OF DIFFERENT BLOCKCHAIN FRAMEWORKS

Blockchain is a revolutionary concept that surfaced to disrupt lots of industries. To find a more secure and private way to manage information over the web, Blockchain has been shown in many cases that it is the perfect answer.

With the widespread popularity of Blockchain technology, we are seeing the number of the Blockchain platforms is increasing time by time. Like any of the other development platforms, the right selection on the platform can greatly help in the development of any project. Forbes released its Blockchain 50 Development Platforms 2019 on 2020 Feb. According to the Blockchain 50, the most widely used platforms in the market are Hyperledger Fabric, Ethereum, Corda, Bitcoin, and Quorum [11]. Many of these platforms are used at the same time for exploration.

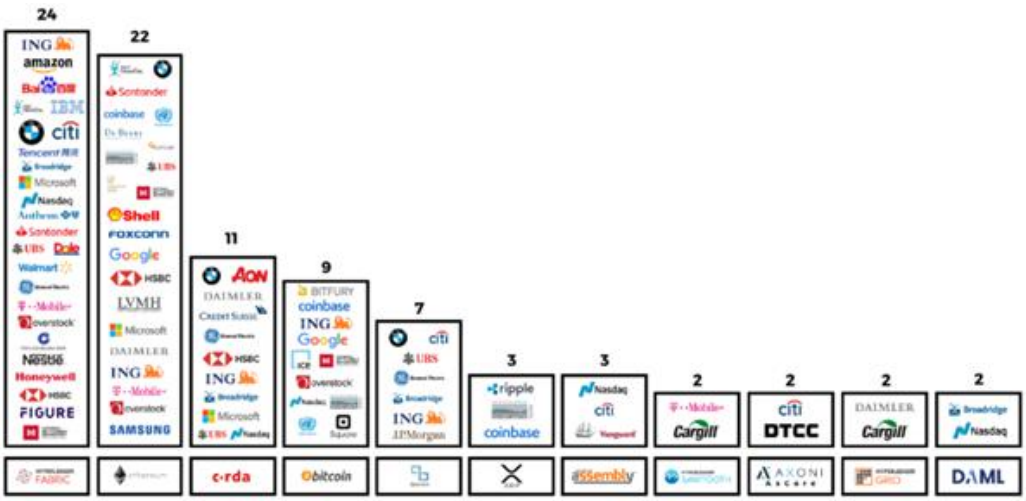

Figure 3: Forbes Blockchain 50 development platforms

2.2.1 INTRODUCTION TO THE MAINSTREAMS

Hyperledger Fabric: Hyperledger is an umbrella project of open-source Blockchains and related tools, started in December 2015 by the Linux Foundation, and has received contributions from IBM, Intel, and SAP Ariba, to support the collaborative development of Blockchain-based distributed ledgers. Fabric is a world-widely used platform in more than 400 protocols and proofs-of-concept, including lots of multinational financial institutions as their consumers, such as Citi Group, Ant Group, UBS, and ING [12].

Ethereum: Ethereum was first developed in 2013 by Vitalik Buterin [13]. Ethereum is a decentralized, open-source Blockchain with smart contract functionality. Ether is the native cryptocurrency of the platform. It is the second-largest cryptocurrency by market capitalization, after Bitcoin. There are many users in financial services are using Ethereum.

Bitcoin: As known as the most famous cryptocurrency in the world. It is developed by Satoshi Nakamoto in 2008. Bitcoin is not just the cryptocurrency itself, but it stands for the external protocol layer, which needs to be separately developed.

R3 Corda: Corda is an open-source Blockchain project, designed for business. Only Corda allows you to build interoperable Blockchain networks that transact in strict privacy. Corda's smart contract technology allows businesses to transact directly, with value.

2.2.2 TECHNOLOGICAL COMPARISON OF THE FRAMEWORKS

In order to make the best choice of the Blockchain platform for our project, we made a general technology comparison among the 4 platforms/frameworks mentioned above.

Platform	Hyperledger Fabric	Ethereum	R3 Corda	Bitcoin
Ledger Type	Consortium	Public	Consortium	Public
Consensus Strategies	Pluggable Framework (Solo, Kafka, PBFT, RAFT)	Proof of Work	Pluggable Framework (RAFT)	Proof of Work
Smart Contracts	Smart contract code (Go, Java, Python)	Smart contract code (Solidity)	Smart contract code (Kotlin, Java) Smart legal contract (Legal prose)	Smart contract code (Bitcoin Script)
Cryptocurrency	None Currency via Chaincode	Ether Tokens via smart contracts	None	Bitcoin
Consensus Strategy Type	PoW	PBFT	Solo	Raft
Transaction Finality	Probabilistic	Immediate	Immediate	Immediate
Fault Tolerance	BFT & CFT	BFT & CFT	NA	CFT

Platform	Hyperledger Fabric	Ethereum	R3 Corda	Bitcoin
Verification Speed	>100s	<10s	<10s	<10s
Throughput (TPS)	Strong	Weak	Weak	Weak

Table 2: Major Blockchain Frameworks

While Bitcoin and Ethereum only support PoW strategy, Fabric, and Corda and adopt the pluggable protocol. Decades of research on consensus protocols have shown there is no "one-size-fits-all" solution [12]. The pluggable architecture does not provide separate components for consensus implementation. On the contrary, the consensus infrastructure is constructed as a combination of services called endorsement and subscription. The pluggable protocol makes the platform more tailored for users. For instance, when the Blockchain banking system is deployed in the bank networks or operated by authorized institutions, a fully Byzantine fault-tolerant consensus might be considered unnecessary and an excessive drag on performance and throughput [14]. Among all frameworks adopting the pluggable protocol, Fabric is the one supporting most consensus strategies, including Solo, Kafka, PBFT, and Raft.

Another point is about cryptocurrency. We do not need a native cryptocurrency to incent costly mining work or to initiate the execution of smart contracts in our project. From the view of security, the exclusion of cryptocurrency reduces some significant risks.

All Blockchain frameworks support the implementation of smart contracts in the form of smart contract codes. The code can be written using Go, Java or Python for Fabric, Solidity for Ethereum. Solidity is the simplest language for decentralized applications, but it is a double blade. Many attacks happened to target the weak structure of Solidity, including DAO attacks, Parity multi-signature wallet attacks, etc. Therefore, Fabric that supports all the most fashionable language comes out to be our choice.

Apart from these, Fabric has many advantages, for example, the structure supports a privilege network, and its membership service manages access to network participants; it provides privacy for groups that need private and confidential transactions. And based on all the features, Fabric is the ideal platform for our project.

2.3 WEB APPLICATION

To accomplish the functions we discuss, we deployed a front-end web application, divided the application into five function units or subpages, and designed the interaction logic of each function. The application can be used by both individuals and authorities. However, they have different levels of access to the functional units.

Functions	Authority user	Individual user
Vaccine Management	✓ Allowed to make changes	✓ Allowed to check
Personal Health Management	✓ See all profiles, add and edit with restrictions	✓ Only allowed to see the profile of itself
System Management	✓ Only authorized user can edit	✖
Information Source	✓	✓
Personal Information	✓	✓

Table 2: Functional Units

A. Vaccine Management

This is a function only the authorized user can make changes to. However, individual users are allowed to check those vaccines which are currently available in the market. For authority users, they can add, edit or delete the attributes of their vaccines in this page, such as traceNo, batchId, manufacturer, date of production, expiration date, vaccination station and createtime. The system will automatically document the createuser, updatetime and updateuser. Therefore, each time a new batch of vaccines is produced, a new block with related attributes can be generated by the producer on our web application. The authority is also allowed to report the follow-up conditions of the vaccine to keep track of it.

B. Personal Health Management:

For authority users, they are allowed to see and manage other users' profiles and edit them with restriction. For individual users, they can only see the health profile of themselves in this page.

Each time a new vaccine is injected into an individual, the authority is obligated to adding the user to our system in this subpage. If the user already exists, the newest condition of the vaccination process should be edited to this person's personal health file. It should include the TraceNo, Name, Birth Date, Vaccine condition, efficacy deadline, COVID-19 Test condition and side effect report. Currently, we only support documenting two kinds of vaccines – Hepatitis B and COVID-19. Future implementation in this function subpage will include recording other types of vaccine condition, generating a health pass for individuals and find the nearest available vaccination station or medical centre to make a reservation for vaccination.

C. System Management

This is a function only admin user (the highest level of authority user) can edit. So the admin user can make changes to the level of access for different users. Currently, there are five kinds of roles in our system: Vaccinators (individual user), Regulators, Medical Centre, Vaccine Manufacturers and Admin.

User Management: Admin can change the role of some user in this subpage.

Role Management: Admin can change the level of access for some role in this subpage.

D. Information Source

Vaccine Information Source: By inputting the TraceNo for a vaccine, users are allowed to check the current condition of a specific vaccine.

Personal Health Source: By inputting the TraceNo for a specific person, users are allowed to check the personal health profile of him or her.

For authority users, they can apply this function to see if the vaccine is correctly updated and whether an individual is already in the vaccination process. For individual users, they can apply this function to check the authenticity of some vaccine or the health record of another individual.

E. Personal Information

Currently, a user can only use the original password to reset his or her password for logging into the system in this subpage. Future implementation in this function subpage will include verifying personal information such as identity card, email address or phone number.

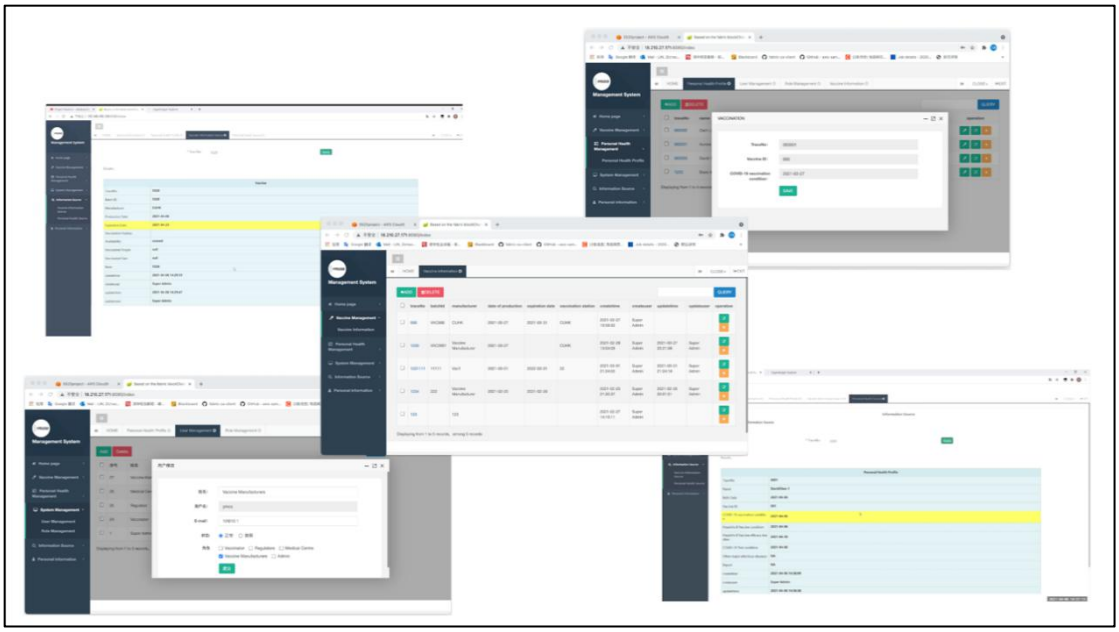

Figure 4: Five Functional Units

2.4 HIGH-LEVEL ARCHITECTURE DESIGN

2.4.1 NETWORK ARCHITECTURE

To accomplish the functions we set, we made a high-level architecture design of the system in the proposal process, dividing the system into functional units, and designing the interaction logic of each unit. There are mainly three units to this project:

1) The Hyperledger Fabric platform: Contains four Fabric Chaincodes programs which respectively process vaccine registration and distribution, vaccine information management, vaccination, and health profile management;

2) Two Web applications, namely for individual users and authorities, each corresponding to an API client by which users can interact with the Chaincodes, providing a simple experience;

3) A Hyperledger Explorer for authorities as the background monitoring system;

All the modules and elements are deployed on an AWS EC2 Ubuntu 18.04 server. We adopt Hyperledger Fabric v1.4 and Java SDK to implement the Chaincode and client application. The front-end is implemented on the HTML and JavaScript framework, interacted by a REST API. Figure 5 shows the high-level architecture of the system.

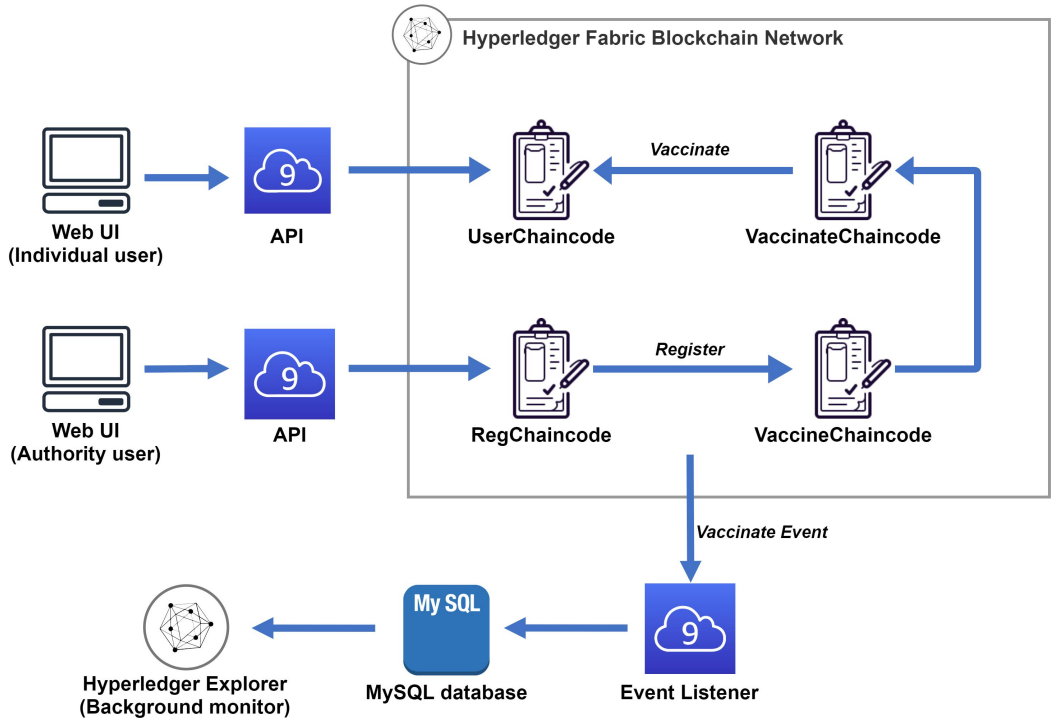

Figure 5: High-level Architecture system

2.4.2 CHAINCODE LEVEL INTERACTIONS

Given the high-level architecture, two Chaincode functions are implemented to achieve the invoke and query Blockchain purpose. The Figure 6 below illustrates the interactions of each component in the network.

A. InvokeChaincode

In the invokeChaincode function is deployed to create new blocks and record the transactions. The first step is to initialize a certificate authority, and then create an admin user. After we enroll the admin user using the CA client, the admin user can operate as a CA&MSP.

The next step is to build a channel. Here we create a fabric client using the previous admin user context, and then a channel client, which will be used to get channel, can be created by the fabric client. We can also get the peer and orderer information from the fabric client, and then add the peer, orderer we created to the channel.

The last step in the invokeChaincode function is message recording. Here our fabric client will create a transaction proposal request and the channel client will then generate a response according to the request. Then our logger will record the response.

B. QueryChaincode

The queryChaincode function is designed to query the block information. What is different from the previous invokeChaincode is that after we get the fabric client and channel client, we will query the block info in the logger using the string key. It will then return the corresponding response from the result generator.

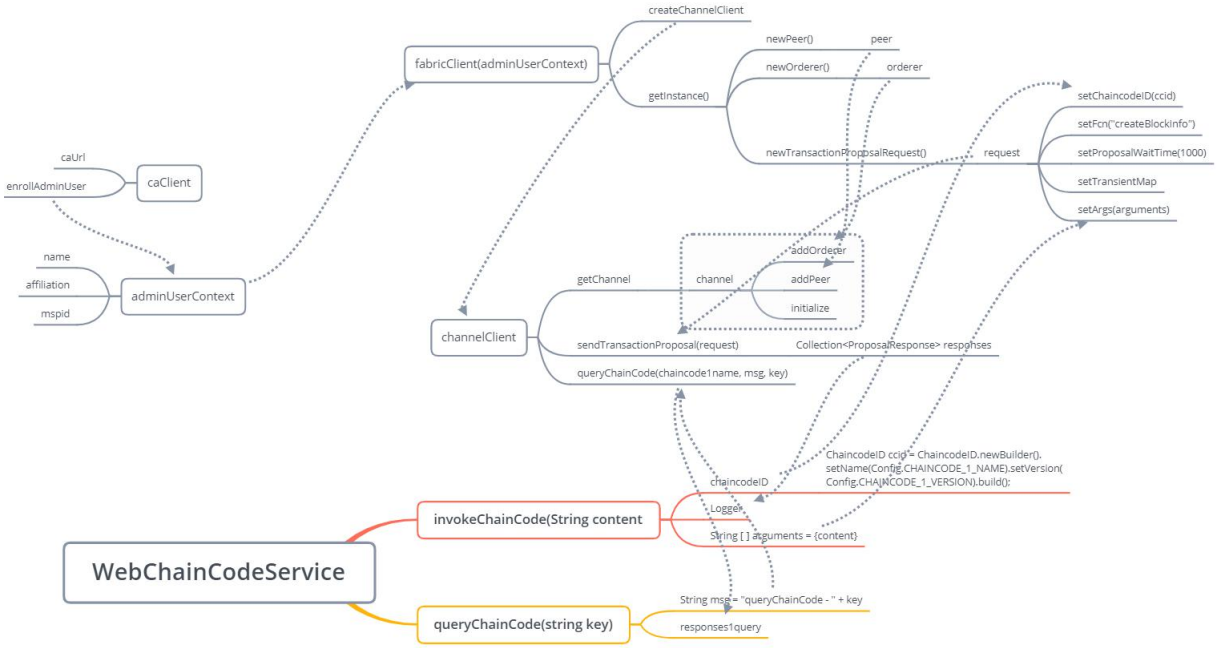

Figure 6: Interactions of each component in the network

2.5 HYPERLEDGER EXPLORER

As one of the core parts of the medical service industry, vaccination management service needs the involvement of regulation. On a Blockchain network, the CDC must have the access to view and monitor the transaction history and current condition to prevent and react to potential emergency situations, also to track the usage of the Blockchain system. Meanwhile, raw Blockchain data is usually in a format that is difficult to read for users without experience, it is necessary to provide an easy visualization by using graphs, charts, pictures, and templates, in addition to the usual search and monitoring facility.

As a preliminary solution, we deployed a background monitoring platform: The Hyperledger Explorer. On this platform, the regulators can see real-time transaction processing, as well as the running condition of different network participants.

Hyperledger Explorer is a user-friendly Web application tool used to view, invoke, deploy or query blocks, transactions and associated data, network information (name, status, list of nodes), Chaincodes and transaction families, as well as any other relevant information stored in the ledger[15]. Figure 7 shows the main page of Hyperledger Explorer.

Hyperledger Explorer includes a web server that runs in the back end, which interacts with all other components and maintains the query service response. The web sockets are used to communicate between the server and the various client components of Hyperledger Explorer. A RethinkDB database is used to store the necessary details about Blockchain components like information about blocks, transactions, and smart contracts, and this can be queried for any necessary information. A security repository takes care of ensuring only secure and authorized access is maintained for accessing the Hyperledger Explorer[16].

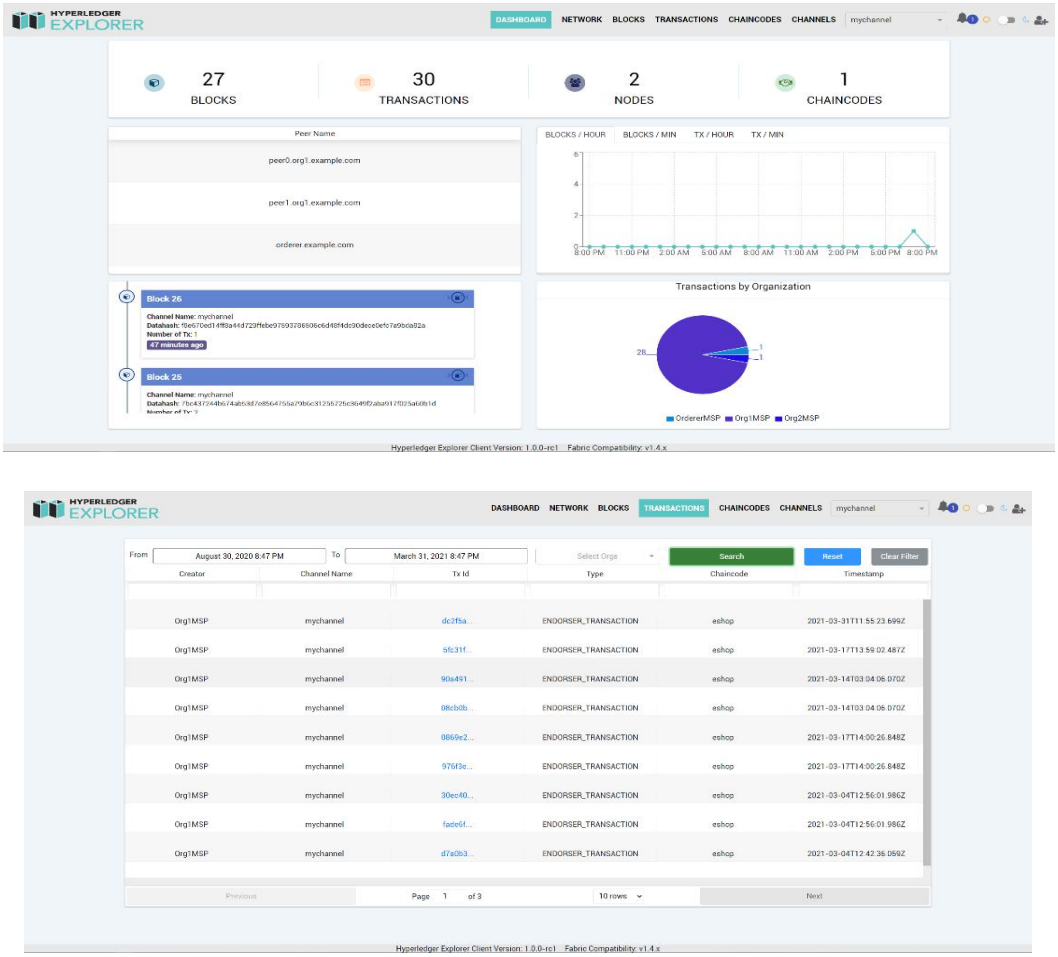

Figure 7: Interface of Hyperledger Explorer

2.6 DELIVERABLES

The deliverable of the project contains 4 parts, which are shown in table 3. For deployment, the user for experimental purpose can refer to the following manual, some dependencies are omitted:

Pseudocode 1: System Deployment
Step 1: Install yum-config-manager, device-mapper-persistent-data and lvm2
Step 2: Set up a stable repository
Step 3: Install docker-ce, set auto-startup
Step 4: Install docker-compose
Step 5: Clone Hyperledger Fabric Git repository
Step 6: Upload eshop_network and eshop_fabric_api
Step 7: Run bootnetwork/start.sh
Step 8: Run fabricJava.jar
Step 9: Run Blockchain-explorer/start.sh

Deliverable Section	Contents	Details
bootnetwork	docker-compose.yml	Configuration of setting up the Blockchain network
	start/stop.sh	A script to start up/close down the network
bootapi	pom.xml	The object model of Maven project
	src	Main root of Maven project
	users	Path for certificate
fabricJava.jar	fabricJava.jar	Packaged jar file for main application
Blockchain-explorer	Blockchain-explorer	Resources for Fabric Explorer

Table 3: Details for Deliverables

2.7 DISCUSSIONS

In this project, we built a prototype of a COVID-19 vaccine management system based on Blockchain technology. However, it has to be realized that the solution still has many limitations and the implementation of blockchain technology in the public health management service industry needs to be further explored. In this section, we will discuss the further possible models and key points for blockchain to energize the industry.

Firstly, because of constraints of manpower and time, the solution only explores the realisation and constructing process of the vaccine management system inside a simple scenario. In real society, the pattern will be far more complex. Meanwhile, we did not mention the regulatory considerations. It is hard to discuss the regulatory issues because most regulators have not yet reached a consensus on blockchain. Another limitation is that the solution does not include the exploration of trust-building on the blockchain. Among the implementation of blockchain on public health services, this problem seems to be particularly important, since it is vital for the public health system to run on a unified platform. However, although everyone follows the rules of the existing system, different governments still have different opinions on how to design and operate the blockchain-based model as a substitute. Therefore, it is a challenge to build linkages among different countries.

Meanwhile, the functionality of the prototype needs to be improved. For further implementation, the function of doctor evaluation system and the digital health pass system still need to be explored.

PWC carried on research in 2018, interviewing 600 executives in 15 areas of the world. According to the result, 84% of the respondents indicated that their companies have at least some exposures to blockchain technology. Companies have invested in experiments, or have completed proof of concept. Everyone is talking about blockchain, for fear of staying behind. However, 85% of them are on processes of research, development, testing, or rather stop the project. The interviewees expressed the following concerns as in figure 5. Among them, regulatory uncertainty, lack of trust among users, and the ability to connect blockchain networks together constitute the main obstacles [17]. The concern of users to blockchain systems and data privacy can be a big topic.

Moreover, the system needs to run in a real scenario, where the log records can be collected and analysed to verify the effectiveness of the system. The implementation of Blockchain technology on public health sector remains challenging.

3 CONCLUSIONS

Since the COVID-19 outbreak in December 2019, the vaccine management system has gradually become an important part of public health management. Researchers from a number of Biopharmaceutical companies or related, are working to develop solutions that leverage existing IT systems and newly developed IT systems with supporting from the government.

This system they wish to design would support COVID-19 vaccine tracking to reliably and rapidly collect data. Vaccine safety is closely linked to public health and national security. However, problems such as expired vaccines and falsified vaccine records remain widespread in the vaccine supply chain. Therefore, a set of effective vaccine supply chain supervision and management system is an urgent need.

Blockchain technology, as a latest technology, aims to provide a new method of information management and verification through its unique trust mechanism. Blockchain technology is characterized by the ability to establish trusted connections and realize data sharing under the premise of privacy protection. It can play an important role in solving data, trust and connectivity problems in the medical systems such as vaccine management system and authentication system.

This project designed a Blockchain platform based on Hyperledger Fabric to manage COVID-19 vaccine within a new, safe and convenient distributed Blockchain system. The system aims to improve the traceability and efficiency of the vaccination process and can be used to address the issue of expired vaccines and falsified vaccine records. At the same time, the paper explores the possibility of implementing a digital health pass based on Blockchain. This report documents the process of research, design, construction and further exploration of specific solutions.

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