PROJECT REPORT

Date	20/11/2023
Team ID	NM2023TMID10093
Project Name	Vaccine Tracking Transparent

CHAPTER 1

INTRODUCTION

1.1 PROJECT OVERVIEW

Coronavirus disease 2019 (COVID-19) has spread quickly and changed the way of life of people all over the world. Building community immunity through vaccination has become mandatory in most countries for the purpose of overcoming the COVID-19 pandemic. Under such circumstances, numerous counterfeit vaccines are circulating because a large amount of money is generated by the global distribution of vaccines. The global market for vaccines is worth approximately 14 trillion Japanese yen [1], and vaccines are commanding enormous sums of money. In July 2021, approximately 2500 people in India received counterfeit COVID-19 vaccines—rather than the real vaccine, these individuals received saline solution [2]. Counterfeit COVID-19 vaccines have also been smuggled across borders, from China to South Africa [3]. In some middle- and low-income countries, where the vaccine supply is insufficient but people can only afford a low-priced vaccine, the probability of inexpensive counterfeit vaccines is relatively high. The circulation of counterfeit vaccines seriously affects human health, the reputation of real VMs, and the effectiveness of the prevention of the spread of COVID-19. Therefore, a strategy for preventing the circulation of counterfeit vaccines is needed.

In this study, to address the abovementioned serious problems, we propose a COVID-19 vaccine tracking system, named "*Vacchain*", by utilizing the characteristics of blockchain technology, such a

decentralization, immutability, and transparency. The notable feature of our proposed Vacchain is that it is able to not only prevent the circulation of counterfeit vaccines but also trace the origin and route of transactions relating to a vaccine before it is even used. Our Vacchain also provides a trusty vaccine passport solution to prevent the circulation of fake vaccine passports.

1.2.PURPOSE

Many people are hesitant to be vaccinated. It has been reported that people are hesitant to receive vaccines because of the negative information that they have been presented with on social media sites about the side effects of vaccines. In other words, anxiety and the fear of foreign-made, fake, and low-quality vaccines have discouraged vaccination . Thus, employing blockchain technology to allow users (USERs) to easily track the origin and quality of vaccines before vaccination is necessary to conduct successful vaccination campaigns. Currently, blockchain is being adopted to address many social issues. For example, Ref. proposed a system to stop the spread of COVID-19 at an early stage. This system provides tokens as an incentive for infected people to voluntarily quarantine themselves. In , the authors developed an Aura blockchain platform to provide proof of authenticity for luxury brand goods, such as Louis Vuitton Moet Hennessy (LVMN). Another study scored the quality of goods and the trust and reputation of entities in the supply chain . In addition, there have been several studies on the integration of Internet of Things (IoT) and Point of Care Tools (POCT) using blockchain. For example, the work in summarized how blockchain technology is being applied to the healthcare system. The work in developed a blockchain model for the IoTs in healthcare. The authors inproposed a high secured blockchain-based

Internet of Medical Devices (IoMT) platform for healthcare. The STAMINA platform described in monitoring and mitigating pandemic outbreaks, which provides the information and tools necessary to take prompt and effective countermeasures in the outbreak period. Regarding vaccine management, the authors inproposed a blockchain system that detects expired vaccines and uses machine learning to perform vaccine evaluation functions and vaccine demand forecasting; however, these authors have not yet discussed any secure method of transferring vaccines through blockchain systems. Therefore, it is necessary to develop a system that allows for the secure transfer of vaccine ownership and the distribution of legitimate vaccines in a feasible manner.

CHAPTER 2

LITERATURE SURVEY

2.1.EXISTING PROBLEM

Many people are hesitant to be vaccinated It has been reported that people are hesitant to receive vaccines because of the negative information that they have been presented with on social media sites about the side effects of vaccines. In other words, anxiety and the fear of foreign-made, fake, and low-quality vaccines have discouraged vaccination Thus, employing blockchain technology to allow users (USERs) to easily track the origin and quality of vaccines before vaccination is necessary to conduct successful vaccination campaigns. Currently, blockchain is being adopted to address many social issues. For example, proposed a system to stop the spread of COVID-19 at an early stage. This system provides tokens as an incentive for infected people to voluntarily quarantine themselves. In,the authors developed an Aura blockchain platform to provide proof of authenticity for luxury brand goods, such as Louis Vuitton Moet Hennessy

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In this study, we propose the use of an SYS-MAN that operates as a guardian to protect vaccine quality. Moreover, we propose a mutual agreement on the transfer of ownership to ensure that vaccine ownership is securely controlled. Furthermore, we employ vaccine passports issued on the blockchain to prevent unjustified vaccine distribution.

2.REFERENCES

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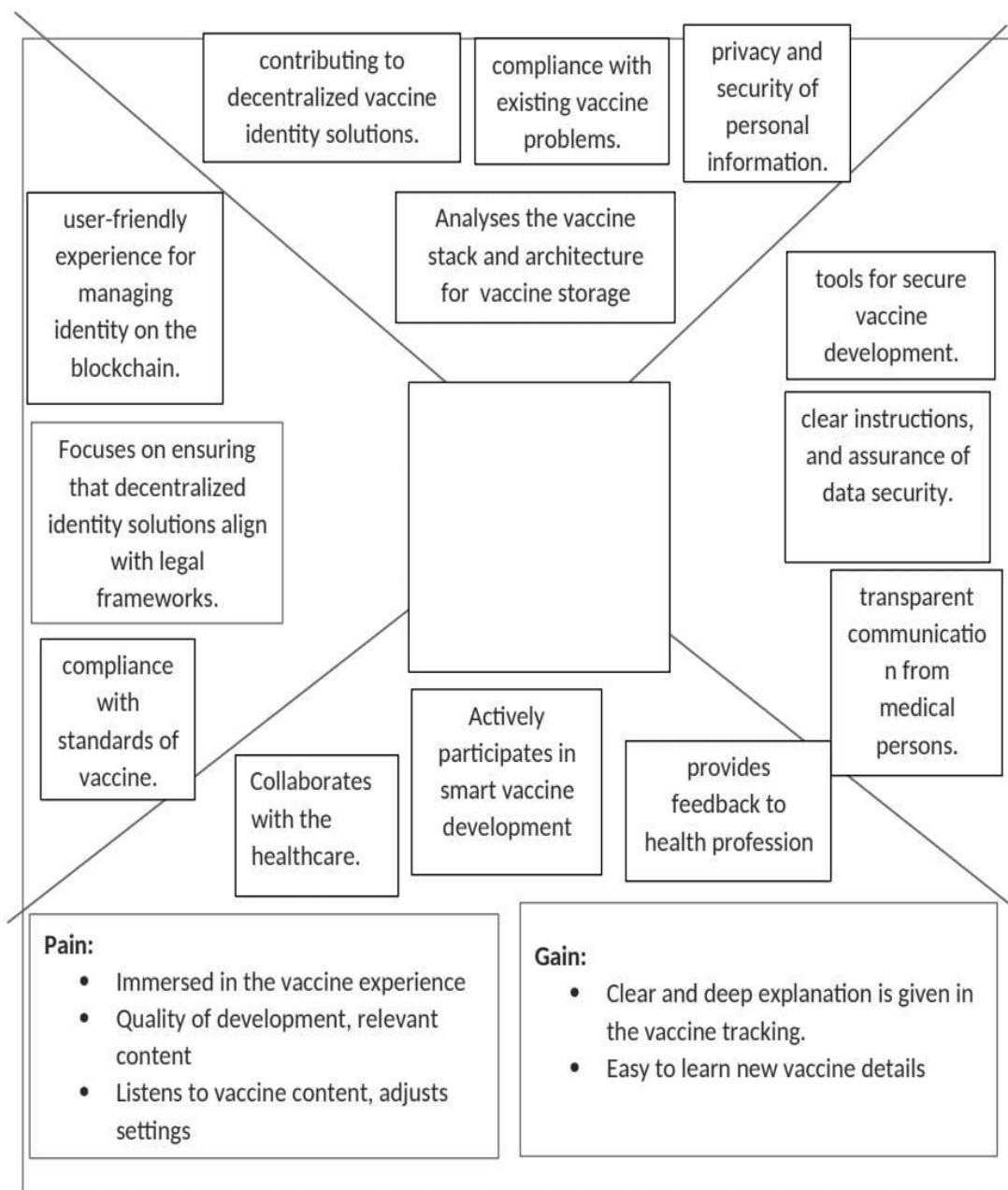
2.3.PROBLEM STATEMENT DEFINITION

Every person's identity document must be issued and verified in a rapid, dependable, and secure manner. The mechanisms already in place are operational, but because the procedure often takes several weeks, the efficiency and security need to be increased. This is not just a hassle and a waste of time, but it's also costly financially and environmentally. The solution for this problem is to detect fake certificates, store certificates and make organizations certificate verification easier without the help of third party. Creating a website using Ethereum blockchain technology that doesn't allow data tampering and which makes storage and validation of certificates easier is a way to create a system that facilitates all the requirements and makes the process of verification and storage simpler.

CHAPTER 3

IDEATION &PROPOSED SOLUTION

3.1 EMPATHY MAP CANVA

Empathy map content:

- contributing to decentralized vaccine identity solutions.
- compliance with existing vaccine problems.
- privacy and security of personal information.
- user-friendly experience for managing identity on the blockchain.
- Analyses the vaccine stack and architecture for vaccine storage
- tools for secure vaccine development.
- clear instructions, and assurance of data security.
- Focuses on ensuring that decentralized identity solutions align with legal frameworks.
- transparent communication from medical persons.
- compliance with standards of vaccine.
- Collaborates with the healthcare.
- Actively participates in smart vaccine development
- provides feedback to health profession

Pain:
- Immersed in the vaccine experience
- Quality of development, relevant content
- Listens to vaccine content, adjusts settings

Gain:
- Clear and deep explanation is given in the vaccine tracking.
- Easy to learn new vaccine details

3.2. IDEATION&BRAINSTROMING

Brainstorm & idea prioritization

Use this template in your own brainstorming sessions so your team can unleash their imagination and start shaping concepts even if you're not sitting in the same room.

- ⏱ **10 minutes** to prepare
- ⧗ **1 hour** to collaborate
- 👤 **2-8 people** recommended

Before you collaborate

A little bit of preparation goes a long way with this session. Here's what you need to do to get going.

⏱ 10 minutes

A **Team gathering**
Define who should participate in the session and send an invite. Share relevant information or pre-work ahead.

B **Set the goal**
Think about the problem you'll be focusing on solving in the brainstorming session.

C **Learn how to use the facilitation tools**
Use the Facilitation Superpowers to run a happy and productive session.

Open article →

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① Define your problem statement

What problem are you trying to solve? Frame your problem as a How Might We statement. This will be the focus of your brainstorm.

⏱ 5 minutes

PROBLEM

How might we [your problem statement]?

Key rules of brainstorming

To run an smooth and productive session

- Stay in topic.
- Encourage wild ideas.
- Defer judgment.
- Listen to others.
- Go for volume.
- If possible, be visual.

2

Brainstorm

Write down any ideas that come to mind
that address your problem statement.

🕐 **10 minutes**

Person 1

Person 2

Person 3

Person 4

Person 5

Person 6

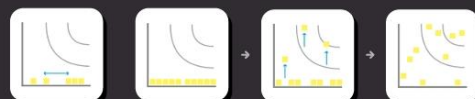**Person 7**

Person 8

4

Prioritize

Your team should all be on the same page about what's important
moving forward. Place your ideas on this grid to determine which
ideas are important and which are feasible.

🕐 20 minutes

Blockchains
are basically
made by a
digital wallets

They can
enable multi-
signature
verification

Importance

If each of these
tasks could get
done without any
difficulty or cost,
which would have
the most positive
impact?

Smart contracts are
stored and executed
on the blockchain
and can be triggered
by events and they
can automate the
complex processes

Decentralized
is a digital
identification
concepts and it
is a self-owned

Feasibility

Regardless of their importance, which tasks are more
feasible than others? (Cost, time, effort, complexity, etc.)

CHAPTER 4

REQUIREMENT ANALYSIS

4.1.FUNCTIONAL REQUIREMENT

Several development platforms are available for developing blockchain-decentralized networks without requiring sophisticated knowledge on the network infrastructure. The first well-known platform is Ethereum , which allows the deployment of smart contracts for developing a distributed application (Dapp). Smart contracts are computer programs that are processed on a virtual computer known as an Ethereum Virtual Machine (EVM). Individuals are able to develop and deploy a Dapp on the existing EVM platform quickly. However, the disadvantage of the Ethereum platform is the high gas fee with a low processing rate. More importantly, the developer is not able to modify the consensus *Cryptography* **2023**, governing the network, meaning that the developer does not have the freedom to upgrade the network's scalability and power consumption.

The second well-known platform is Substrate [11] provided by Polkadot [12]. In Sub strate, components such as the consensus model and governance methods are modularized. One may combine the elements appropriate for their specific requirements. Therefore, the Substrate is characterized by its flexibility in the development process. Developers can utilize open-source Substrate to build their own blockchain network and may choose either to develop applications with the above-provided consensus for saving development time or even to develop a new consensus algorithm for enhancing network scalability, interoperability, and security.

The development of a blockchain network requires knowledge in many research fields, such as cryptography, data encryption, decentralized networking, and P2P communication. Therefore, it is very difficult to create such a platform from scratch. In this study, we develop our system from an open-source Substrate. We do not choose the Ethereum platform because, in the near future, we plan to enhance network scalability, interoperability, and security, which is not relevant to applications on the Ethereum platform. Therefore, Substrate is our best choice at the moment.

4.2.NON-FUNCTIONAL REQUIREMENT

The second publication, An Overview of Blockchain Technology [15], gave further information about Blockchain. It defined a number of words related to this technology, including the most crucial idea known as a smart contract. The Blockchain generates a long chain of nodes and stores the data's hash in the block before it. When data is changed, its hash will modify and cease to correspond to the value recorded in the preceding block, alerting us to the change. Blockchain and Smart Contract for Digital Certificate was the title of the third paper. There were 3 actors in their design. Institutions came first, followed by students, and then service providers. Their strategy had the drawback of using "one hash as a key," making it available to anyone with the hash. Next up is our tamper-proof birth certificate document. With the exception of using the AES technique and IPFS to store the data, their concept was essentially identical to that of the second paper. They specifically designed their system for birth certificates. The problem was that neither the original document nor the capability to create certificates online were ever stored anywhere. We investigated a distinct paper with the title BlockIPFS (Blockchain enabled Interplanetary File System for Forensic and Trusted Data Traceability) to address the issue of document storage
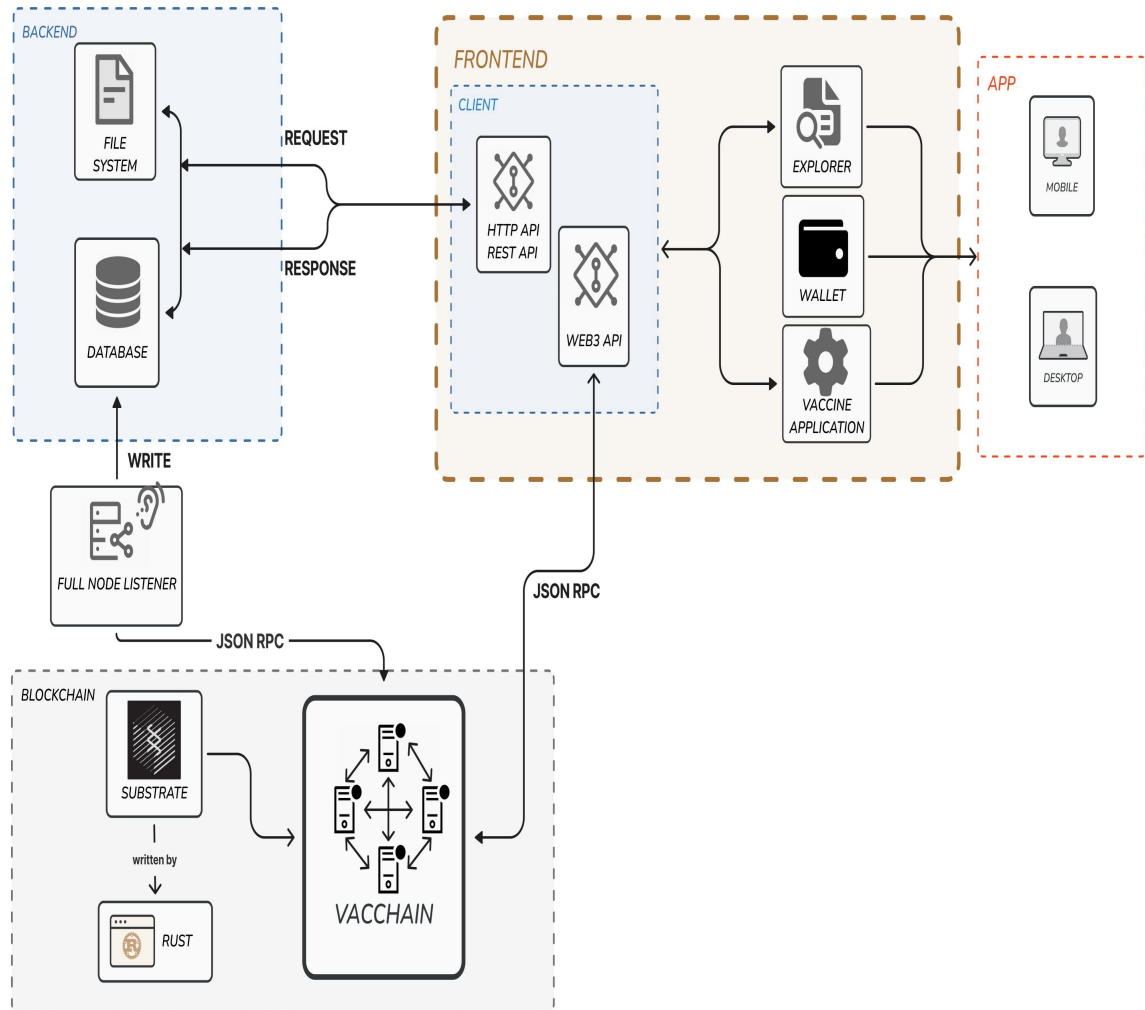
CHAPTER 5

PROJECT DESIGN

5.1.DATA FLOW DIAGRAM
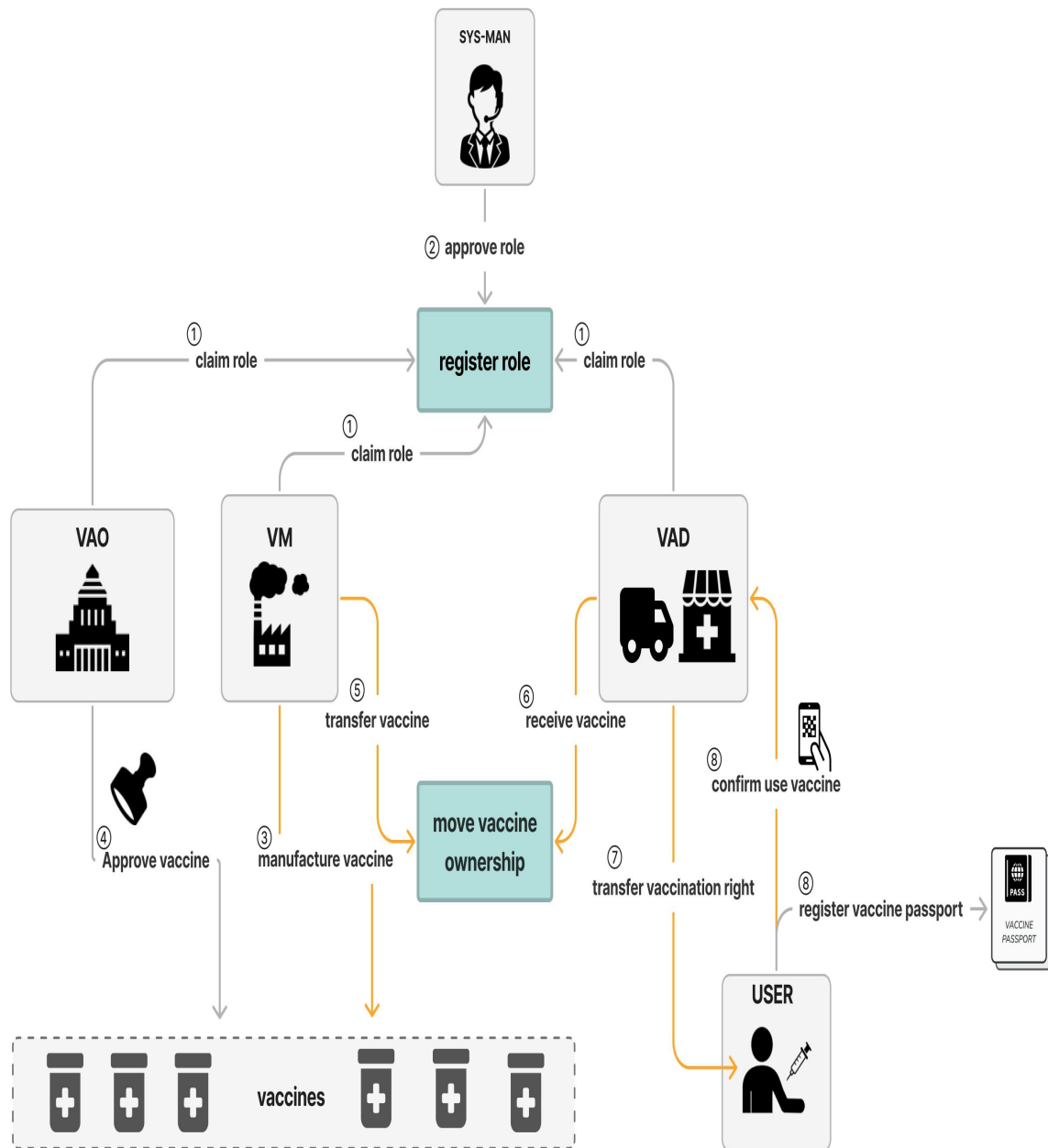
5.2.SOLUTION ARCHITECTURE

CHAPTER 6

PROJECT PLANNING AND SCHEDULING

6.1 TECHNICAL ARCHITECTURE

The overall diagram of the proposed system is shown in Figure 7. The system is comprised of three parts: frontend, blockchain, and backend. The frontend part provides an intuitive and user-friendly interface that allows USERs to interact with data in the blockchain and backend parts. We develop the frontend part mainly by using the JavaScript language.The backend is responsible for storing the data registered on the blockchain in a local database through a full-node listener. Storing blockchain data in an off-chain backend database enables not only faster access to the data but also the searching, filtering, and sorting of on-chain data quickly. The backend part of our Vacchain system is used to manage USER accounts and sign-in and sign-out tasks. We develop the backend part mainly by using the Typescript language. The blockchain part is the most important part of our system, as it stores and manages the distributed Vacchain database. We develop the blockchain part on the Substrate platform by using the Rust language. We utilize the Aura + GRANDPA consensus, which is the default consensus on the Substrate platform. Aura is actually a simple version of Proof of Stake by a round-robin process concerning the tasks of validators, whereas GRANDPA is a block finality mechanism that has been proven to be secured by Polkadot public networks. The nodes join the system as evaluators to secure the network and receive the reward coins in return for their hard work. Most of our original ideas are implemented in the blockchain part. The following subsections describe in more detail how we implement the blockchain part as well as new ideas such as the *SYS-MAN* and *mutual agreement on transferring ownership*.

CHAPTER 7

CODING&SOLUTION

7.1 FEATURE 1

VS CODE

```
{
// Use IntelliSense to learn about possible attributes.
// Hover to view descriptions of existing attributes.
// For more information, visit:
https://go.microsoft.com/fwlink/?linkid=830387
"version": "0.2.0",
"configurations": [
  {
    "type": "node",
    "request": "launch",
    "name": "Jest All",
    "program": "${workspaceFolder}/node_modules/.bin/jest",
    "args": ["--runInBand"],
    "console": "integratedTerminal",
    "internalConsoleOptions": "neverOpen",
    "windows": {
      "program": "${workspaceFolder}/node_modules/jest/bin/jest"
      }
```

```json
    },
    {
      "type": "node",
      "request": "launch",
      "name": "Jest Current File",
      "program": "${workspaceFolder}/node_modules/.bin/jest",
      "args": ["${relativeFile}", "--detectOpenHandles"],
      "console": "integratedTerminal",
      "internalConsoleOptions": "neverOpen",
      "windows": {
        "program": "${workspaceFolder}/node_modules/jest/bin/jest"
      }
    },
    {
      "type": "node",
      "request": "launch",
      "name": "Launch Program",
      "skipFiles": ["<node_internals>/**"],
      "program": "${workspaceFolder}/lib/index.js",
      "preLaunchTask": "tsc: build - tsconfig.json",
      "outFiles": ["${workspaceFolder}/lib/**/*.js"]
    },
```

```json
  {
    "type": "node",
    "request": "launch",
    "name": "test revoker",
    "skipFiles": ["<node_internals>/**"],
    "program": "${workspaceFolder}/node_modules/.bin/jest",
    "args": ["revokerTests"]
  },
  {
    "type": "node",
    "request": "launch",
    "name": "test basic",
    "skipFiles": ["<node_internals>/**"],
    "program": "${workspaceFolder}/node_modules/.bin/jest",
    "args": ["basic"]
  }
 ]
}
```

7.2 FEATURE 2

GITHUB

name: Build, Test and Publish

on:

```yaml
  workflow_dispatch:
  push:
    branches:
      - 'master'
      - 'alpha'
jobs:
  build-test-publish:
    runs-on: ubuntu-22.04
    steps:
      - uses: actions/checkout@v4
        with:
          fetch-depth: 0
          token: ${{ secrets.GH_TOKEN }}

      - name: "Setup node with cache"
        uses: actions/setup-node@v4
        with:
          node-version: 18
          cache: 'yarn'

      - run: yarn install --frozen-lockfile
      - run: yarn run build
```

```
- name: "Setup git coordinates"

  run: |

    git config user.name ${{ secrets.GH_USER }}

    git config user.email ${{ secrets.GH_EMAIL }}


- name: "Run semantic-release"

  env:

    GH_TOKEN: ${{secrets.GH_TOKEN}}

    NPM_TOKEN: ${{secrets.NPM_TOKEN}}

  if: github.ref == 'refs/heads/master' || github.ref == 'refs/heads/alpha'

  run: yarn run relea
```

CHAPTER 8

PERFORMANCE TESTING

SYS-MANs operate as guardians of the network; they verify the role requested by entities and allow only trusted entities to update the database according to their confirmed roles. For example, *VM A* is able to execute functions designed for manufacturers only and must take full responsibility for its registration and updated information since every action is immutably recorded as concrete evidence. If an entity works dishonestly, then the SYS-MAN has permission to remove the account from the network

by revoking the role of that entity. In other words, the existence of an SYS-MAN helps enhance the data security and reliability of the network. It is worth noting that the SYS-MAN is able to decide only whether to approve or revoke the role of the requested entities. Network miners, not SYS-MANs, are able to create a new block of the blockchain ledger. Therefore, the network still is decentralized in nature. If vaccine ownership could be unilaterally sent without the approval of the recipient, then it would be impossible to assign responsibility when irregularities related to the vaccine are discovered. In other words, even if a defect is found in the vaccine and the proposed system is used to trace the vaccine to identify the cause, it might be difficult to track down the cause because of the imposition of responsibility. The mutual agreement mechanism can be used to address these problems. The transfer of vaccine ownership is done by mutual agreement, making it possible to trace the vaccine and to clearly identify who is responsible for its management. In addition, since the owner of the vaccine at a given point in time is clearly specified, the system can be applied to the implementation of extended functions, such as those functions that can be performed only by the owner of the vaccine.*Cryptography* **2023**As previously mentioned, a vaccine handled on the blockchain may not always be legitimate. Therefore, we propose the issuance of a vaccine passport to eliminate the advantage of distributing counterfeit vaccines. However, although this mechanism is expected to be effective against fraud involving replicating vaccines, it cannot detect the presence of foreign substances or illegally exported entries. In other words, it is difficult to completely prevent fraud outside the blockchain. However, this system makes it possible to trace vaccines so that if they are found to be counterfeit or deficient vaccines, they can be traced back to the original source. This situation increases accountability while discouraging.

CHAPTER 9

9.1 OUTPUT SCREENSHOTS
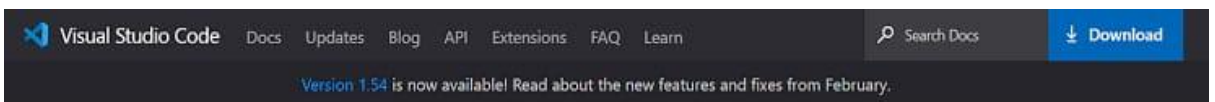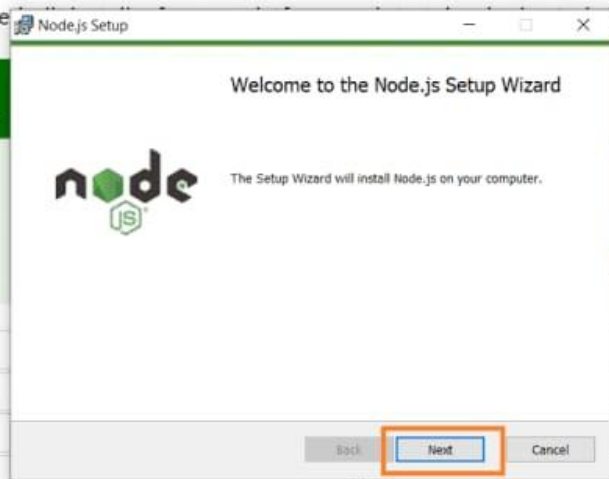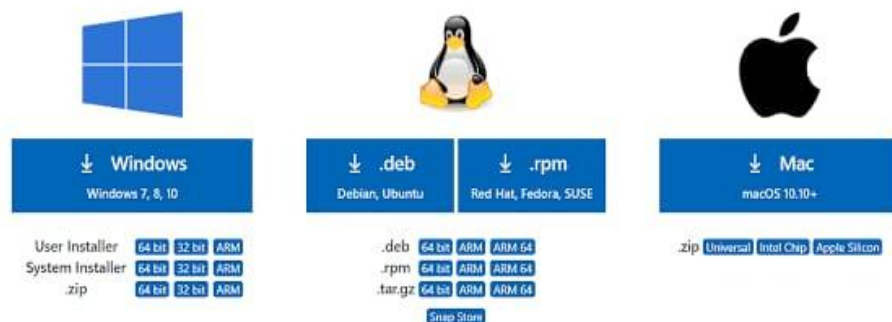
CSE Department, GNITS

Choose file to upload

Choose File | Certificate2.png

947328

Submit

Get Transaction Receipt

Tx Receipt Category	Values
IPFS Hash # stored on Eth Contract	QmXDhJu2LJf9enDw6CNLmcCQBNBMuQ6gM1L8a1xuMCwyV2
Ethereum Contract Address	0x919E5b5Fb7040E6bC7F0c214B34EDdeB6547123a
Tx Hash #	0x334bdb126c52b34e7c1dd97f44e606114db399291492e4dc93d9514d38126ea0
Block Number #	24
Gas Used	84286

CHAPTER 10

CONCLUTION

In this study, we develop a highly secure decentralized system for vaccine distribution. To enhance system security and data reliability, we propose three mechanisms: an SYS MAN, the mutual agreement of vaccine ownership, and a vaccine passport. The SYS-MAN approves or revokes the role of entities who join the system. The mutual agreement manages the transfer of vaccine ownership. The vaccine passport eliminates the need to circulate counterfeit vaccines. We implement and evaluate the network on the open source Substrate platform. Theoretically, the system is highly secure due to the use of the abovementioned three proposedmechanisms. Our testing also shows that the system operates smoothly. However, Vacchain still has limitations that should be addressed in the future. For example, Vacchain does not yet focus on solving the fundamental issues of blockchain tech nology, such as consensus, processing throughput, storage size, and scalability. Our future work will aim to enhance the scalability and processing rate of the system. Furthermore, upgrading the network consensus is our next research theme. We fully expect a bright future where there is no use for counterfeit vaccines.

CHAPTER 11

FUTURE SCOPE

Coronavirus disease 2019 (COVID-19) vaccines play a crucial role in preventing the spread of the disease. However, the circulation of low-quality and counterfeit vaccines seriously affects human health and the reputation of real vaccine manufacturers (VMs) and increases the amount of fear concerning vaccination. In this study, we address this problem by developing a blockchain-based COVID-19 vaccine tracking system called "***Vacchain***". Our Vacchain allows users (USERs) to track and trace the route of vaccines. We propose three mechanisms, namely, a system manager (SYS-MAN), a mutual agreement concerning vaccine ownership, and vaccine passports, toenhance the security and reliability of data recorded in the Vacchain ledger. We develop this system on the Substrate platform with the Rust language. Our implementation, evaluation, and analysis have shown that Vacchain can trace and track vaccines smoothly. In addition, data security and reliability are enhanced by the above mentioned three mechanisms. The proposed system is expected

to contribute to preventing the spread of COVID-19.