

# **A STUDY ON EFFECTIVE VACCINE SUPPLY CHAIN MANAGEMENT USING BLOCKCHAIN**

A thesis submitted in partial fulfilment of requirements for the  
award of the degree of

**B.Tech**

in

**Computer Science and Engineering**

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# **BONAFIDE CERTIFICATE**

This is to certify that the project titled **Effective Vaccine Supply Chain Management using Blockchain** is a bonafide record of the work done by

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## **ABSTRACT**

In the current scenario, where the covid-19 virus has been wrecking havoc worldwide, it has become crystal clear how valuable timely vaccination is for survival. Data related to the vaccination processes, such as vaccine identification and the number of vaccinated people, is critical to the production and distribution of vaccines in a way to achieve the desired immunization required to fend off a disease efficiently.

We propose a reliable approach to create a vaccine management system using blockchain technology. We create different fields of data that are filled up by the producers and can be verified by the consumers to check whether the vaccine they receive is legit or not. Blockchain would be an ideal technology to implement this because of its decentralization and anti-tamper functionalities.

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## **Reason For Choosing This Project?**

The growing need for reliance on vaccines also gives birth to mismanagement of the vaccine doses, in which case counterfeit vaccines can enter the supply chain, and can be administered to unknowing consumers which is extremely harmful. Centralized management of vaccines is also susceptible to fraud and tamper.

There is no way for citizens to cross-check the authenticity of the vaccine they are being administered by the healthcare provider. Similarly, there is no way for healthcare providers to verify the authenticity of the vaccines that they receive from the manufacturers. Counterfeit Vaccines can enter the supply chain during the transportation of the vaccine.

This problem is solved by using a decentralized Vaccine Supply Chain Management System. Blockchain, with its distributed, decentralized ledger system provides unalterable record when data changes hands.



## **Blockchain and Reasons for choosing it**

The growing need for reliance on vaccines also gives birth to mismanagement of the vaccine doses, in which case counterfeit vaccines can enter the supply chain, and can be administered to unknowing consumers which is extremely harmful. Centralized Management of vaccines is also susceptible to fraud and tamper. Blockchain, with its distributed, decentralized ledger system provides unalterable record when data changes hands.

### **What is Blockchain?**

A blockchain is a growing list of records, called blocks, that are linked together using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data (generally represented as a Merkle tree). The timestamp proves that the transaction data existed when the block was published in order to get into its hash. As blocks each contain information about the block previous to it, they form a chain, with each additional block reinforcing the ones before it. Therefore, blockchains are resistant to modification of their data because once recorded, the data in any given block cannot be altered retroactively without altering all subsequent blocks.

Blockchains are typically managed by a peer-to-peer network for use as a publicly distributed ledger, where nodes collectively adhere to a protocol to communicate and validate new blocks. Although blockchain records are not unalterable as forks are possible, blockchains may be considered secure by design and exemplify a distributed computing system with high Byzantine fault tolerance.

## **Types of Blockchains: -**

- **Public blockchains:** - A public blockchain has absolutely no access restrictions. Anyone with an Internet connection can send transactions to it as well as become a validator (i.e., participate in the execution of a consensus protocol) Usually, such networks offer economic incentives for those who secure them and utilize some type of a Proof of Stake or Proof of Work algorithm. Some of the largest, most known public blockchains are the bitcoin blockchain and the Ethereum blockchain.
- **Private blockchains:** - A private blockchain is permissioned. One cannot join it unless invited by the network administrators. Participant and validator access is restricted. To distinguish between open blockchains and other peer-to-peer decentralized database applications that are not open ad-hoc compute clusters, the terminology Distributed Ledger (DLT) is normally used for private blockchains.
- **Hybrid blockchains:** - A hybrid blockchain has a combination of centralized and decentralized features. The exact workings of the chain can vary based on which portions of centralization decentralization are used.
- **Sidechains:** - A sidechain is a designation for a blockchain ledger that runs in parallel to a primary blockchain. Entries from the primary blockchain (where said entries typically represent digital assets) can be linked to and from the sidechain; this allows the sidechain to otherwise operate independently of the primary blockchain (e.g., by using an alternate means of record keeping, alternate consensus algorithm, etc.)

## **Advantages of using Blockchain in this system: -**

- **Security:** - Blockchain's security is one of its strongest assets. Each transaction in the supply chain is documented, and no modifications are allowed. This unalterable chain of data helps to pre-vent the development of counterfeit drugs from entering the supply chain as well as stops data from being altered.
- **Consumer Confidence:** - Blockchain enables the transparency necessary to attaining a complete, unified view of the data. By eliminating any data gaps, the entire supply chain becomes an open book with total visibility into each step, allowing key stakeholders to monitor the process and ensure quality. Blockchain also enables effective data management and can ensure that all key stakeholders can access the data securely. This allows the consumer to gain a confidence about the legitimacy of the vaccine they are about to receive.
- **Efficiency:** - A supply chain fueled by unified data is more streamlined and efficient than one that relies on stakeholders to ensure data is kept complete. Blockchain prevents information loss during each handoff and mitigates the introduction of erroneous data such as assets being counted twice, both of which cause shipping delays. With greater transparency across the process, delivery times can be reduced without data being lost.

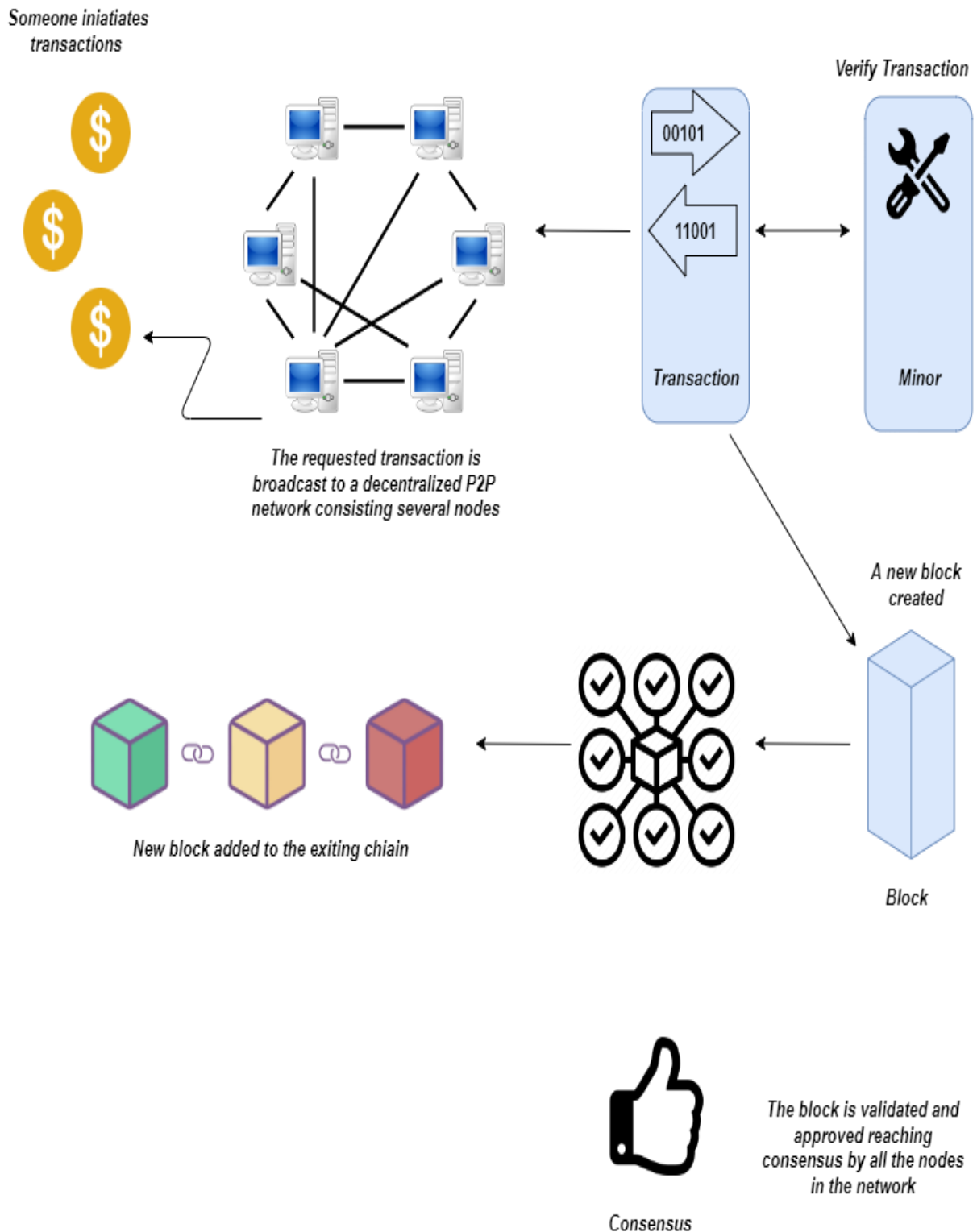
## **Working Of a Blockchain**

Blockchain essentially functions as a ledger for storing a set of information. All blockchain transactions that serve the function specified by the user are known as transactions. The node is the user or peer in the network. And all of the nodes, when combined, form a peer-to-peer decentralized chain/network. When a node requests service, miners mine to solve the puzzle, forming a block, and are compensated based on the complexity of the puzzle. The network adheres to consensus protocols such as the proof of stake or proof of work algorithms. Each block formed is visible to all nodes in the network, and each node is expected to confirm the block being created.

## **Components Of Blockchain**

- **Node:** -The user or users involved in the blockchain network, as well as each of the nodes, are meant to be given a copy of the entire blockchain ledger.
- **Transaction:** -the requests made by the node for a specific service to be performed.
- **Block:** - A data structure that is used to keep track of the activities that are recorded in the ledger.
- **Chain:** -A sequence is formed by arranging blocks in a specific order.
- **Miners:** -Miners are specific nodes that validate transactions and new blocks that are created and added to the existing blockchain network.

- **Consensus Protocol:** -While conducting operations on the blockchain network, a series of agreements were followed.



**Figure 1:** Components of a Blockchain

## **Decentralized Consensus (Proof of Work)**

An algorithm that compels miners, or specialized network nodes, to solve an arbitrary mathematical puzzle in order to prevent anybody from mastering the system. Mining a block is often exceedingly expensive (in terms of computing) since it acts as "Proof of work" or "Decentralized Consensus." A hacker must have a 51 percent more powerful system than the network owner in order to hijack the system or upload a new malicious block constructed using the Decentralized Consensus method. The block chain connects the ordinary user with the network administrators, and each individual user receives an update on what is going on in the system, ensuring perfect transparency among network participants.

### **How Proof of Work works**

The client requests a service or function, and the request is sent to the server. The server selects a random puzzle or challenge for the client to solve or mine, and the client sends the solution to the server, and the server verifies whether the solution is legitimate, and if it is, the service is granted. So, in our application, every time a network user logs in, a node is created, and each transaction is notified to every member of the network. Additionally, each node in the chain is unique and cannot be altered.

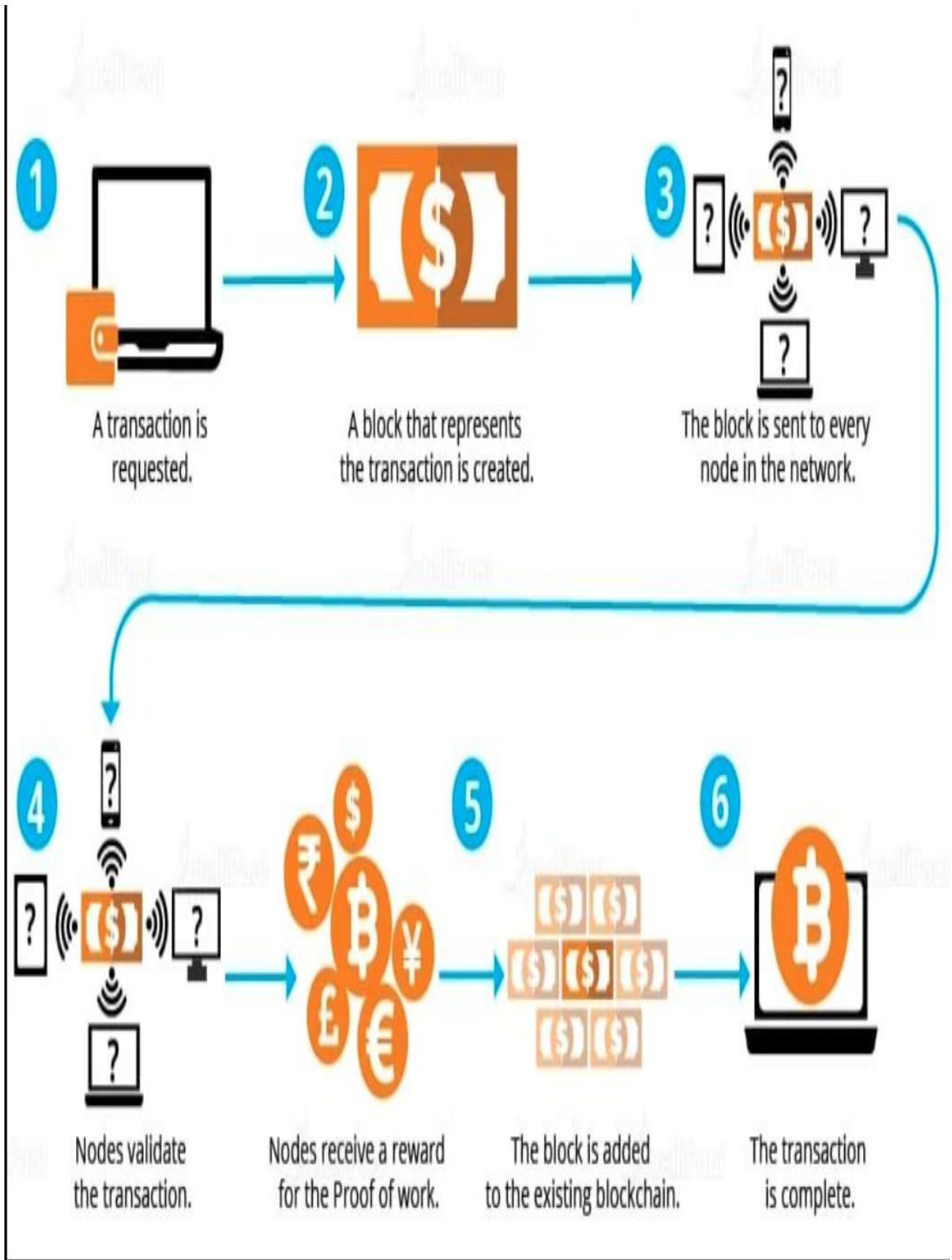


Figure 2: Working of a Blockchain

## **Technologies used**

The Vaccine Management System is built on the Ethereum Blockchain, and written in Solidity. The development was done using Truffle and Ganache.

### **Ethereum**

The Vaccine Management System is based on Ethereum. Ethereum, conceived by Vitalik Buterin in 2013, is a decentralized, open-source blockchain with smart contract functionality. It uses the blockchain to store application code and smart contracts rather than have the sole purpose be for recording transactional information. So instead of a decentralized platform for financial transactions.

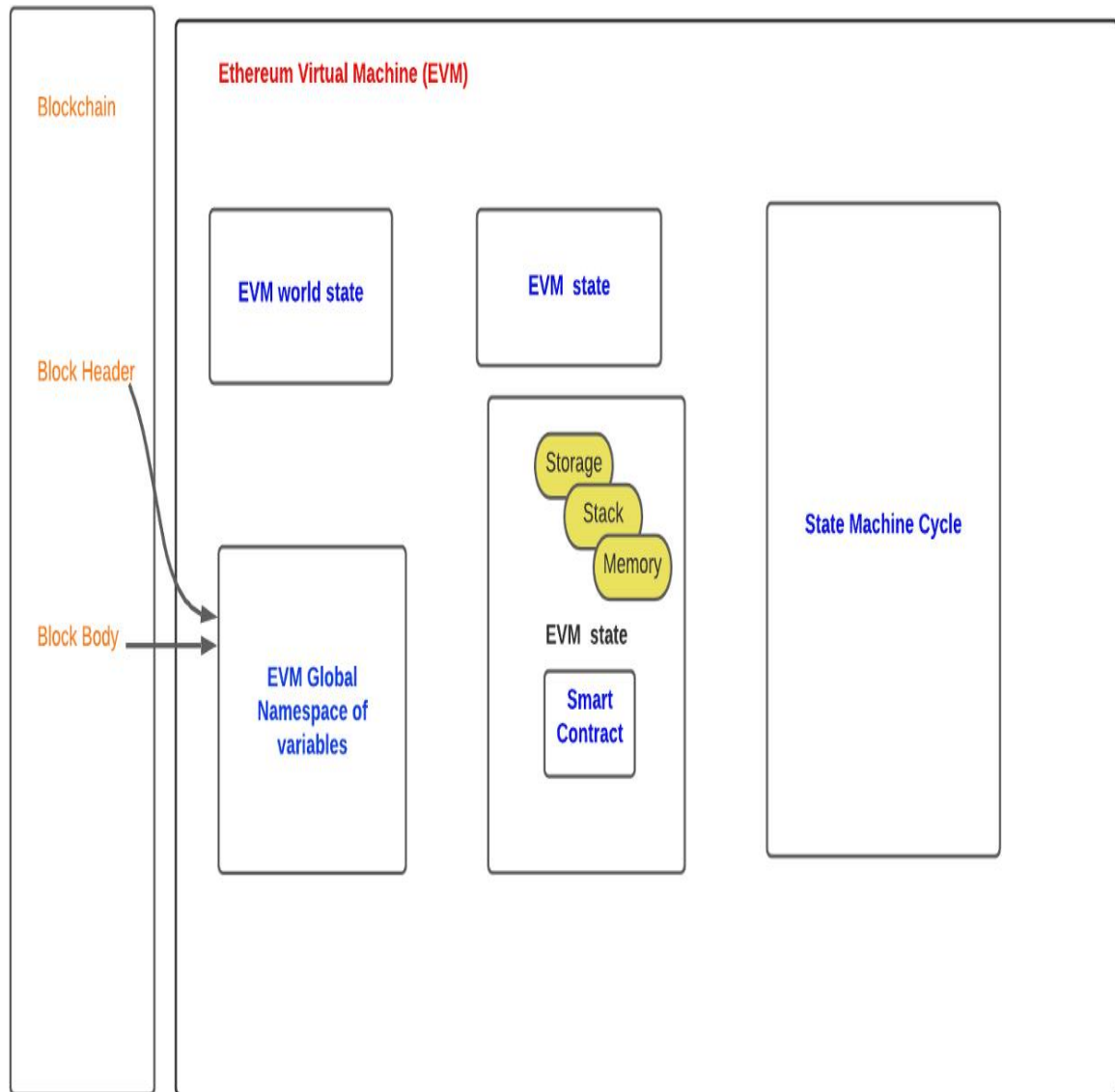
Ethereum is an open-source blockchain on which Ether is the token that can be mined. As per the Ethereum site, “Ethereum is the community-run technology powering the cryptocurrency, ether (ETH) and thousands of decentralized applications”. The core engine that powers Ethereum is the Ethereum virtual machine (EVM). It is a blockchain software platform that uses Smart Contract to validate transactions of Ethereum blocks.

### **Ether**

Ether (ETH) is the cryptocurrency generated by the Ethereum protocol as a reward to miners in a proof-of-work system for adding blocks to the blockchain. It is the only currency accepted in the payment of transaction fees, which also go to miners. The block reward together with the transaction fees provide the incentive to miners to keep the blockchain growing (i.e. to keep processing new transactions). Therefore, ETH is fundamental to the operation of the network. Each



Ethereum account has an ETH balance and may send ETH to any other account. The smallest subunit of ETH is known as a Wei, named after cryptocurrency pioneer Wei Dai, and is equal to  $10^{-18}ETH$ .



**Figure 3:** Ethereum Virtual Machine

## **Smart contracts**

Smart contracts permit trusted transactions and agreements to be carried out among disparate, anonymous parties without the need for a central authority, legal system, or external enforcement mechanism. A smart contract is a self-executing contract with the terms of the agreement between buyer and seller being directly written into lines of code. The code and the agreements contained therein exist across a distributed, decentralized blockchain network. The code controls the execution, and transactions are trackable and irreversible.

Smart contracts permit trusted transactions and agreements to be carried out among disparate, anonymous parties without the need for a central authority, legal system, or external enforcement mechanism.

## **Solidity**

Solidity is an object-oriented, high-level language for implementing smart contracts. Smart contracts are programs which govern the behavior of accounts within the Ethereum state.

Solidity is a curly-bracket language designed to target the Ethereum Virtual Machine (EVM). It is influenced by C++, Python and JavaScript. You can find more details about which languages Solidity has been inspired by in the language influences section

## **Truffle**

Truffle is a world-class development environment, testing framework and asset pipeline for blockchains using the Ethereum Virtual Machine (EVM), aiming to make life as a developer easier.

Truffle is widely considered the most popular tool for blockchain application development with over 1.5 million lifetime downloads. Truffle supports developers across the full lifecycle of their projects, whether they are looking to build on Ethereum, Hyperledger, Quorum, or one of an ever-growing list of other supported platforms. Paired with Ganache, a personal blockchain, and Drizzle, a front-end dApp development kit, the full Truffle suite of tools promises to be an end-to-end dApp development platform.

## **Ganache**

Ganache is a personal blockchain for rapid Ethereum and Corda distributed application development. You can use Ganache across the entire development cycle; enabling you to develop, deploy, and test your dApps in a safe and deterministic environment.

Ganache comes in two flavors: a UI and CLI. Ganache UI is a desktop application supporting both Ethereum and Corda technology. The command-line tool, `ganache-cli` (formerly known as the `TestRPC`), is available for Ethereum development.

## Architecture

### The components of our model: -

- **Government module:** -Each transaction's hash value is saved in the government module. This makes it simple to track all of the app's operations, such as test information, user registration, health care official registration, vaccine booking, and the number of vaccines accessible in the hospital. According to the proof of work algorithm utilized, the admin with the most network power in this system becomes the controlling authority.
- **Manufacture Module:** - Manufacture module registers itself and gets verified by the government module. Once verified, it can now add supply of different types of vaccines and also accept the order of vaccines from government verified hospitals. Manufacture module will be responsible for production of vaccine, logistics and quality assurance.

```
struct Manufacturer {  
    uint id;  
    string name;  
    address payable owner;  
    string vaccine;  
    uint capacity;  
    uint gstNo;  
    uint doseCost;  
    bool isCreated;  
    bool isValidated;  
}
```

Figure 4: Manufacturer Module

- **Hospital Module:** - Hospital module registers itself in that site and gets verified by the government. After being able to do the following functionality, give vaccines to any citizen who book appointments under that hospital. Order a vaccine to a particular

manufacturer and after getting the vaccine from the manufacturer increase their respective vaccine stocks. Also able to set a fixed price for any vaccine of a particular type.

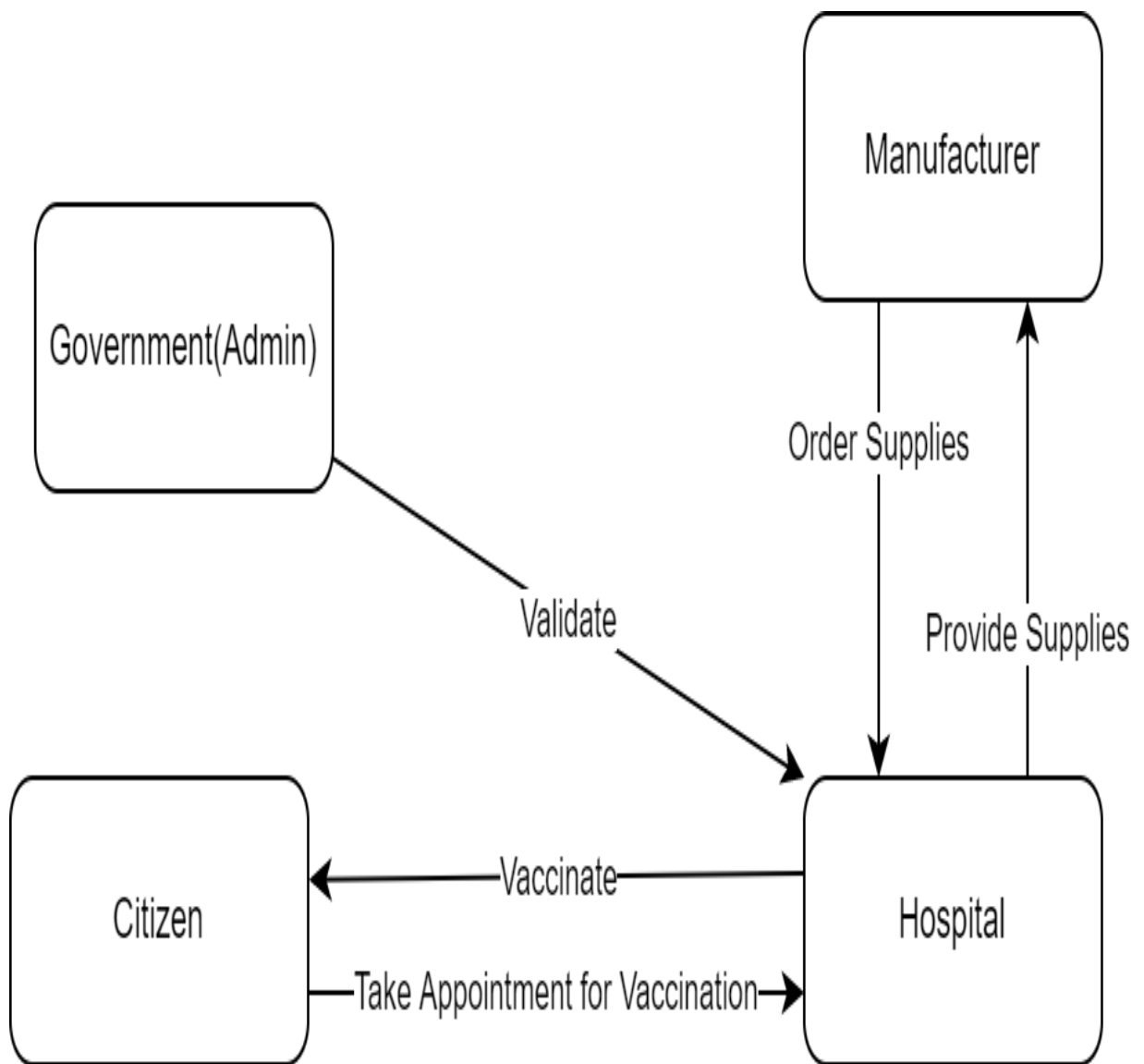
```
struct Hospital {  
    uint id;  
    string name;  
    address payable owner;  
    bool isValidated;  
    string vaccine;  
    uint stock;  
    uint nabhID;  
    uint doseCost;  
}
```

**Figure 5:** Hospital Module

- **Citizen Module:** - The user registers his/her account using their respective Aadhar number which makes it easier to keep track of the people getting vaccinated. Once the user registers, he needs to book an appointment at the verified hospitals for a particular type of vaccine in order to get vaccinated. After the hospital approves the appointment, he will be successfully vaccinated and will receive the vaccination certificate.

```
struct Citizen {  
    uint id;  
    string name;  
    address public Address;  
    string vaccine;  
    bool vaccinated;  
    uint doses;  
    bool isCreated;  
}
```

**Figure 6:** Citizen Module



**Figure 7:** High Level Design of the Vaccine Management System

## Screenshots from our model: -

Vaccine Management

0x70c660c7764Db99B287D877b506C12A04Ce2a98C

### Manufacturer List

#	Name	Address	vaccine	capacity	isValidated	gstNo	doseCost
0	Bharat Biotech	0x92Fe8518D7B832dE30a6Fa65397c82e8F77Ce86C	Covaxin	500	true	56777894	700

### Register Manufacturer

Name

Vaccine Name

Gst NO

Vaccine Per Dose Cost

Submit

### Add Supply

Quantity

Submit

Vaccine Management

0x5F6fCC65Ea4D181c435839eE5Bfd7B3fC04e0cFd

## Appointment List

#	date	citizenId	hospitalId	vaccine	DoseCount
1	12-06-22	0	0	Covaxin	1



Vaccine Management

0x70c660c7764Db99B287D877b506C12A04Ce2a98C

## Citizen

#	Name	Address	Vaccine Status	Dose
0	Ashis Ghosh	0x70c660c7764Db99B287D877b506C12A04Ce2a98C	false	1
1	Arpan Layek	0x4B3b798D5867a796C79a03aa230e1dc061C97D73	true	1

## Register Citizen

Name

Submit

## Book Appointment

Jalpaiguri Super Hospital



Submit

## Hospital List

#	Name	Address	isValidated	Vaccine	stocks	DoseCost
0	Jalpaiguri Super Hospital	0x72bCDB010F13BAFd0d55cD3C337c8a62bc259Fb9	true	Covaxin	400	750
1	Bankura Hospital	0x5F6fCC65Ea4D181c435839eE58fd7B3fC04e0cFd	false	Covishield	300	1200

### Register Hospital

Name

Vaccine Name

NABH ID

Dose Cost

### Place Vaccine Order

Covaxin



Quantity of Vaccine

### Vaccinate Citizen

Ashis Ghosh



## Vaccine Management

### Government

#### Validate Hospital

Jalpaiguri Super Hospital ▼

Submit

#### Validate Manufacturer

Bharat Biotech ▼

Submit

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