Mini Project - I Report
on
ZENO - Supply Chain and Logistics DAPP for Asset Tracking

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Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Acknowledgements

We feel great pleasure in presenting the stage one report of our mini-project titled ‘ZENO: Supply Chain and Logistics DAPP for Asset Tracking’. We have channelized our best efforts towards a systematic approach to the project, keeping in mind the aim we need to achieve.

We are highly grateful to our project Guide Prof. Varsha Hole, Department of Information Technology, Sardar Patel Institute of Technology (SPIT) for constant encouragement, effort and guidance. She has always been involved in discussing our topic at each phase to make sure that our approach was designed and carried out in an appropriate manner and that our conclusions were appropriate, given our results.

Abstract

In recent years there have been increased efforts to make supply chains transparent and traceable to better protect the end consumer's interests against counterfeiting, contamination, false claims, and inadequate processes. Managing the integrity of products and processes in a multi-stakeholder supply chain environment is a significant challenge. Many current solutions suffer from data fragmentation, lack of reliable provenance, and diverse protocol regulations across multiple distributions and processes.

Blockchain is a technology that can allow authenticated data communication between each player in a supply chain without the intermediation of a trusted central organization. Throughout the project, we have reviewed existing digitilisation of the supply chain and developed a solution to answer the queries raised. Furthermore, we have automated many complex functions such as releasing payments, recording ledger entries, and flagging exceptions in need of manual interventions through smart contracts, to verify contractual obligations have been fulfilled and payments can be issued. It is important to note that blockchain would not replace the broad range of transaction-processing, accounting and management-control functions performed by ERP systems. Instead, blockchain would interface with legacy systems across participating firms.

By verifying and adding data in real-time, blockchain can increase transparency across a supply chain. Blockchain can greatly improve supply chains by enabling faster and more cost-efficient delivery of products, enhancing product traceability, improving coordination between partners, and aiding access to finances.

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1. Introduction

1.1 PROBLEM DEFINITION:

COVID-19 has disrupted supply chains around the world. But they've also been a vital lifeline to support the response, keeping essential medical supplies, food and other key necessities flowing where they're needed most. There's no doubt that the pandemic has tested the ingenuity, resilience and flexibility of supply chain leaders globally, as they have sought to maintain essential operations. The following problems have been identified by our team which need to be addressed:

- **Complex, fragmented, under pressure**

Products reach consumers through a chain of companies involved, which typically includes manufacturers, logistics firms – who provide storage, distribution and transport – and retailers. Not surprisingly, the whole system is highly complex.

- **Disrupted Market**

COVID-19 resulted in significant geographical shifts in supply and demand, which in turn has created problems for finely tuned global supply chains. Trends that were apparent pre-pandemic, such as increases in online shopping and driver and other skill shortages, are now causing real problems. Second, the economic and business environment became more challenging. For example, in the UK and the rest of Europe, supply chain pressures were caused by Brexit as a result of increases in red tape and cross-border checks. More widely, firms continue to grapple with a range of international business challenges ranging from fluctuating exchange rates to the building of global management teams.

- **Transparency and Traceability**

Companies are under pressure from governments, consumers, NGOs, and other stakeholders to divulge more information about their supply chains, and the reputational cost of failing to meet these demands can be high. For example, food companies are facing more demand for supply-chain-related information about ingredients, food fraud, animal welfare, and child labour.

1.2 LITERATURE SURVEY

- Nowadays, [9] counterfeit products are growing exponentially online and black-market. The block market is the biggest challenge in the supply chain. The government regulations cannot control counterfeit products. Therefore, there is a need for an approach for detecting counterfeit products and providing security techniques to alert both manufacturer and consumer in the supply chain.

- A smart contract is a software code written within every block to ensure immutable and transparent applications and also eliminate the need for middlemen and saves a lot of time and money. [4] For example, if two parties are willing to buy and sell a property then they need a middle man, the physical appearance of all the parties, need to spend a lot of time and money and paperwork. Still, there are chances of fraud in such an environment. Smart contracts eliminate all these issues by making contracts on the Blockchain network.

- The main purpose of [6] is to integrate most of the parts of a supply chain of a manufacturing industry that leads to a green economy. The mathematical model shown in this paper is applicable for any type of product at different stages of the supply chain in different time periods. Computational experiments show that when the number of returned products increases, the total profit increases.

1.3 MARKET SURVEY

- Companies are under pressure from the government, consumers, NGOs, and other stakeholders to divulge more information about their supply chains, and the reputational cost of failing to meet these demands can be high. [3]

- Over the last decade, numerous scandals have inflicted considerable damage on the reputations of companies. Notable examples include the Rana Plaza factory collapse in the fast fashion industry, slave labour in the Thai seafood industry, and deforestation in Malaysia and Indonesia. Further reporting revealed the Thai fishing industry's extensive misuse of workers. Supposedly, these workers experienced poor working conditions and confinement similar to a prison. In fact, workers were receiving pay below the minimum wage and not obtaining payments on time.[2]

- If transparency is a growing business imperative, why aren’t more companies doing it and why is the transition to transparent supply chains so slow? One reason is supply chains were not designed to be transparent. Companies and suppliers have feared that divulging too much information would undermine their competitive advantage or expose them to criticism. [1]

1.4 OBJECTIVES AND SCOPE

OBJECTIVES:

1. **Increased supply chain transparency**

Supply chain networks can be limited by one-up/one-down visibility. Through distributed ledger technology that provides a shared, single version of the truth, Blockchain supply chain solutions give permissioned participants greater visibility across all supply chain activities

2. **Build a resilient supply chain**

One unexpected event can cause a cascading array of supply chain disruptions. Blockchain supply chain solutions use smart contracts that automatically trigger when pre-defined business conditions are met. This gives near real-time visibility into operations, and the ability to take action earlier.

3. **Streamlined supplier onboarding**

New supplier onboarding is a time-consuming, manual experience for both buyers and sellers in a supply chain. IBM Blockchain supply chain solutions can speed this process through an immutable record of new vendor details that business network participants can trust.

SCOPE:

1. Crowdfunding sector
2. Insurance claims
3. Banking - Finance sector
4. Business Scalability - B2B
5. Auctions - Safe auctions and avoid third-party auctioneers

1.4 ASSUMPTIONS

The biggest obstacle in establishing a blockchain-based supply chain has less to do with technology. What makes it difficult to scale is the number of parties that you need to involve is very high. Our project aims to tackle the problem under the assumption that the number of parties involved must be lessened over time.

1.5 CONSTRAINTS

Given the huge investments by industry, greater academic research is needed which investigates potential implications and supports companies. In this report and project, various research questions are addressed and solutions have been proposed for the same.

2. Proposed System

2.1 ARCHITECTURE

Participating Authorities in considered Network:

1. **DigiChamber:** Responsible for issuing and verification of Certificates of Origin
2. **Manufacturers:** Responsible for providing raw materials to the network
3. **Distributors:** Responsible for delivering the goods from one location to another
4. **Retailers:** Responsible for ideating products and the whole workflow
5. **Customers:** End-user of the whole supply chain network

Smart Contracts Architecture:

The system consists of commonly 3 types of smart contracts (according to use cases):

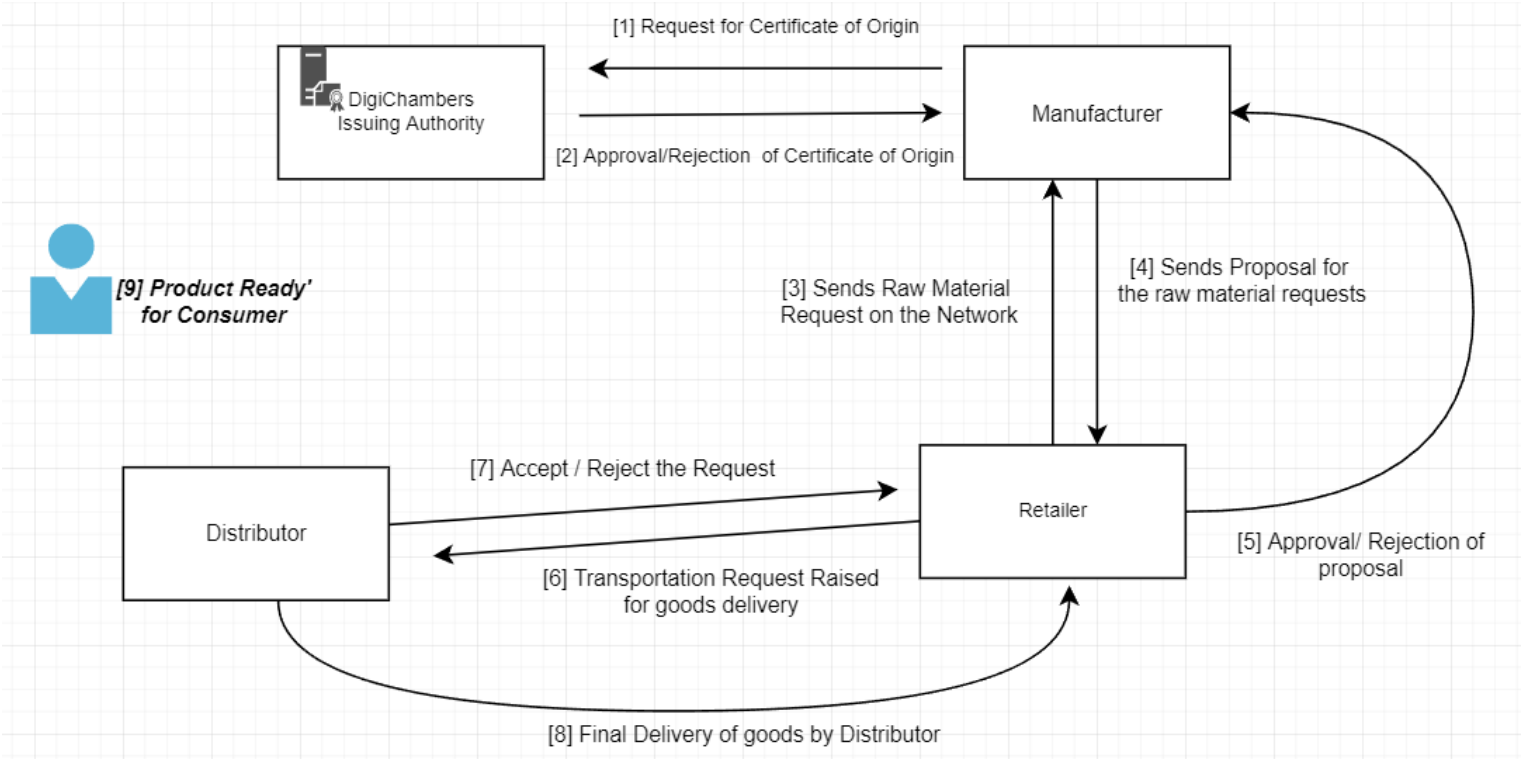
1. Smart Contracts Factory
2. CoO Issuing Authority (DigiChambers)
3. Instances of Smart Contracts for each node in the supply chain

Architecture Layers:

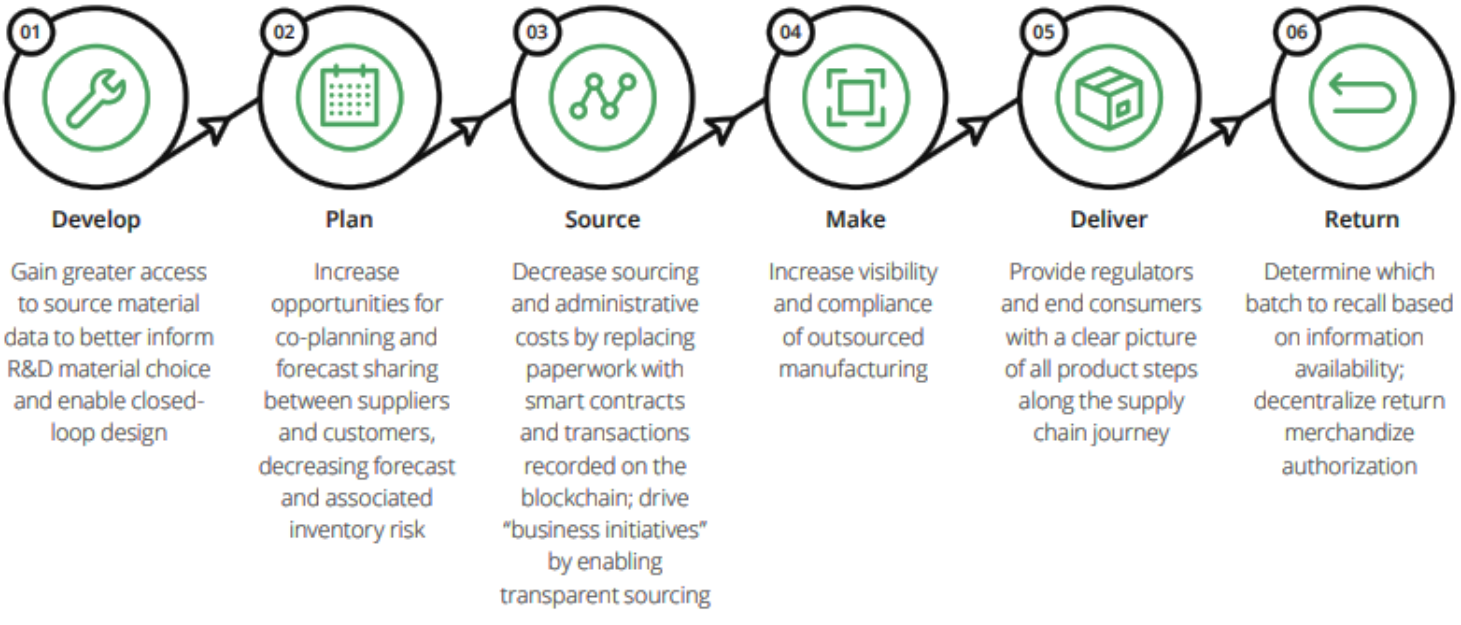
The System has layered architecture, consisting of High Layers dealing with the user interface and Lower layers connecting with the blockchain network and web server.

1. **Application Layer:**
   Binds services together with application-specific logic for powerful Apps
2. **Services Layer:**
   Connects applications with interface APIs for specific needs like payment processing
3. **Interface Layer:**
   Modular APIs for reading and writing data include: Document, data query, data transit
4. **Permissions and ID Layer:**
   Wraps the core application in blockchain backed-access control logic
5. **Transport Document Core:**
   Consists of smart contracts and additional logic, acting as control of shipment or any kind of data

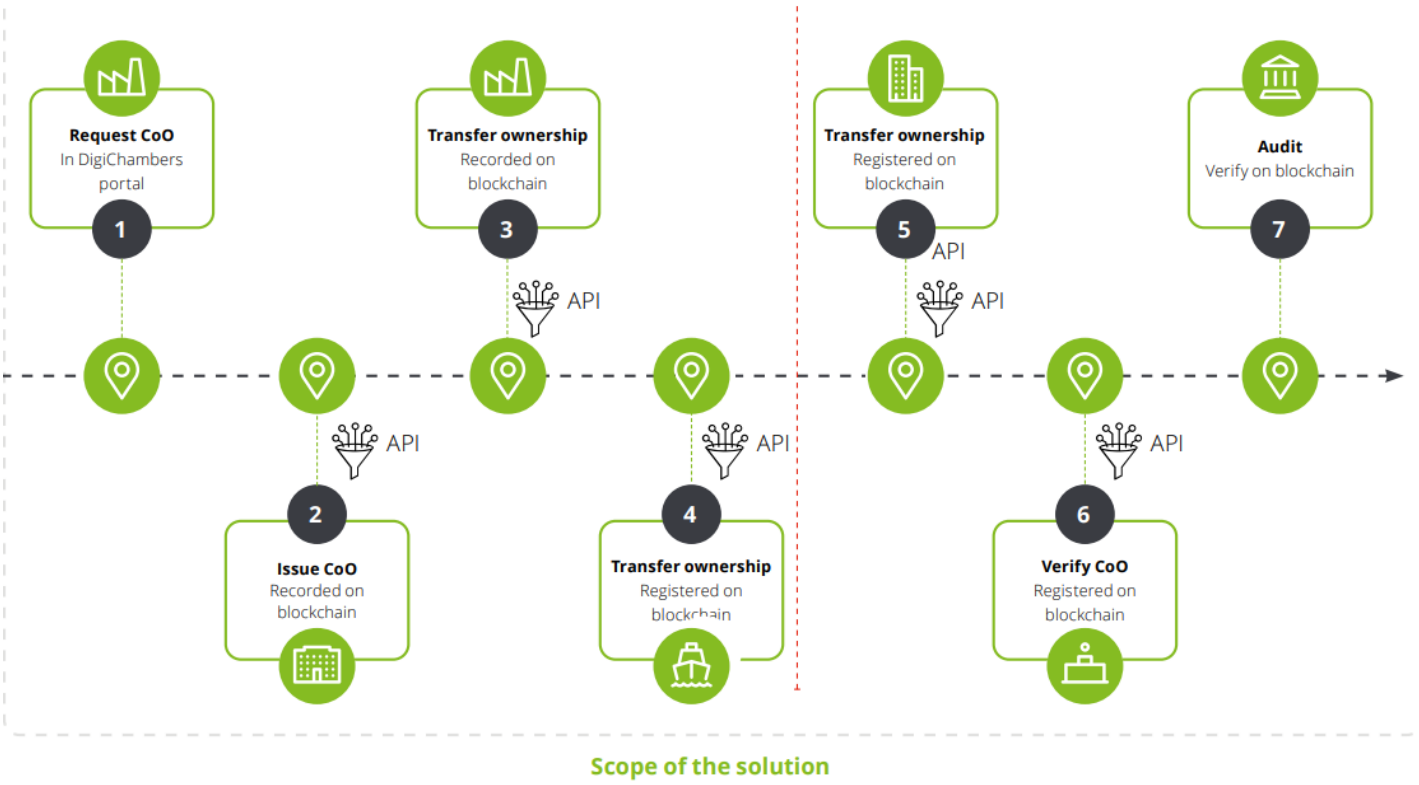
Timeline of Events:



Common Workflow within the system:



Certificate of Origin Issuing Process:



Points not addressed above:

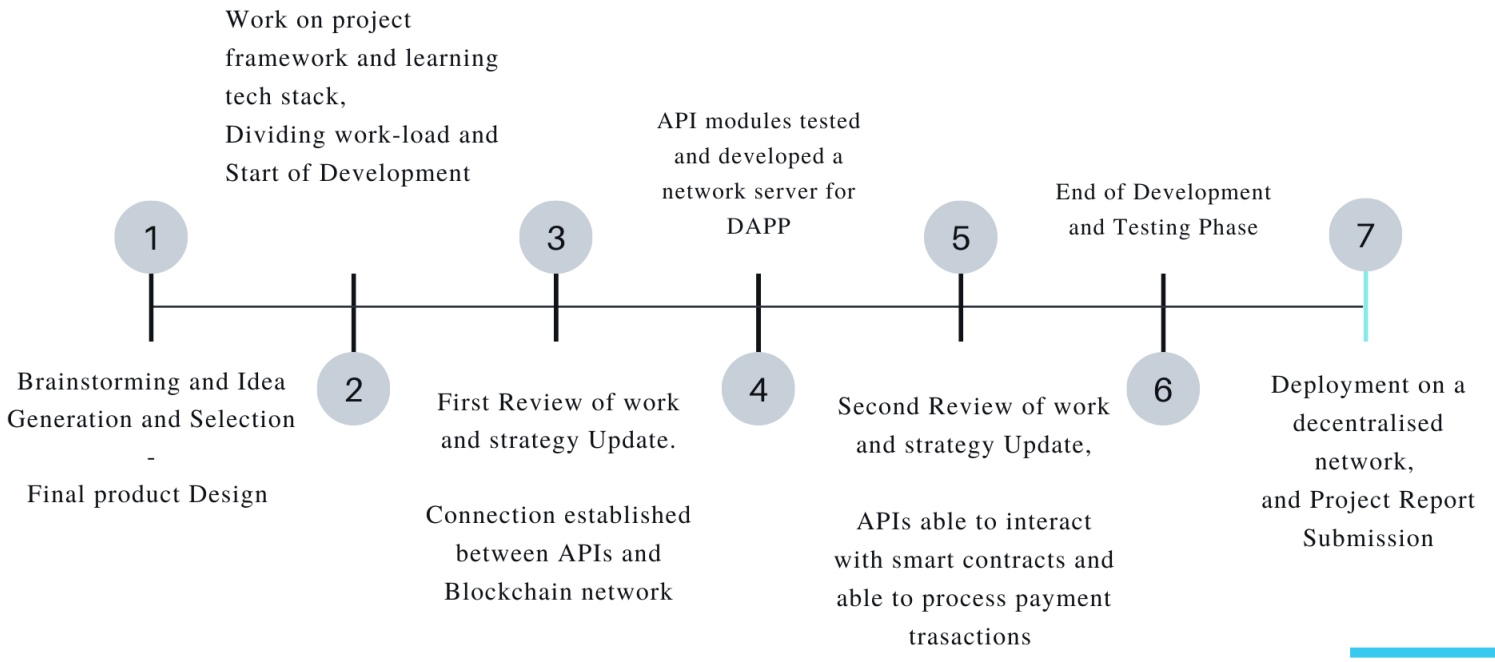
[1] Whenever a transportation request or Raw material request has been sent on the network, A sender needs to pay the gas fee as well as the token amount to the respective smart contract instance.

[2] Payment transactions are being done fully automated in the system, still when the need arises the manual interception can be done. Ether amounts held by the smart contract instances are not withdrawable, and can only be transferred to the next party or returned to the owner.

[3] An alphanumeric and symbolic hash has been used to issue certificates of origin, This can be replaced by RFID tags, QR codes or NFC tags, according to the financial investments by the involved parties.

3. Project Plan

Week Wise Timeline and Modules:



Tasks Completed module wise:

1. Research Paper selection and title selection [Week 1]
2. Final Product Design [Week 2]
3. Development Server implementation [Week 3]
4. Connection setup with Local blockchain network [Week 3]
5. Integrating Development Server and Local Blockchain network [Week 4]
6. Designing API architecture details [Week 4]
7. Implementation of API architecture in MVC framework pattern [Week 5]
8. Implementation of User Interface for DAPP [Week 5]
9. Integration of backend services and User interface of DAPP [Week 6]
10. Deployment and testing of the system [Week 6]
11. Resolving bugs found in the testing phase [Week 6]
12. Final project report submission [Week 7]

4. Implementation

1. Implementation Details

API architecture Details:

1. **Level 0:**
   authentication and authorization APIs
   It dealt with processes such as user registration and logging into the system and provide seamless integration

2. **Level 1:**
   To perform critical functionalities of the System such as dealing with cloud databases and local blockchain
   It dealt with functionalities such as issuing of Certificates of Origin and updating the asset transaction details on the network

3. **Level 2:**
   To keep the system in check, routine security checks

Smart Contracts Architecture Details:

1. **Contracts Factory Smart Contract:**
   Deploys instances of other smart contracts

2. **DigiChambers Smart Contract:**
   Issues Certificate of Origin and verification, auditing of CoO

3. **Implementation based Smart Contracts:**
   a. Product Smart Contracts
   b. ProductRequests Smart Contracts
   c. TransportRequests Smart Contracts
   d. Manufacturers Smart Contracts
   e. Distributor Smart Contracts
   f. Retailer Smart Contracts

Detailed Explanation:

Basic View APIs

- GET localhost:1000/
- GET localhost:1000/login
- GET localhost:1000/signup
- GET localhost:1000/authenticate

Manufacturer Actions APIs

- GET localhost:1000:/manufacturer-page
- POST localhost:1000:/manufacturer/produce-material
- POST localhost:1000:/manufacturer/send-raw-material-tender

Retailer Actions APIs

- GET localhost:1000/retailer-page
- POST localhost:1000/retailer/create-product
- POST localhost:1000/retailer/setup-raw-material-request
- POST localhost:1000/retailer/approve-raw-material-proposal
- POST localhost:1000/retailer/confirm-fulfillment-of-request

DigiChambers Actions APIs

- GET localhost:1000/DigiChambers-page
- POST localhost:1000/digichambers/approve-reject-certificate
- POST localhost:1000/digichambers/verify-certificate

Distributor Actions APIs

- GET localhost:1000/distributor-page
- POST localhost:1000/distributor/accept-request

To start the application, we can use following commands :
npm start / npm run, which instantiates application on port 1000 and connects the application instance to the cloud MongoDB atlas and local ganache blockchain network.

Any failure in the connection may hamper the application's performance throughout the various stages.

2. Tech Stack used

Local Blockchain Network: Ganache CLI server, Truffle suite

Programming Languages:

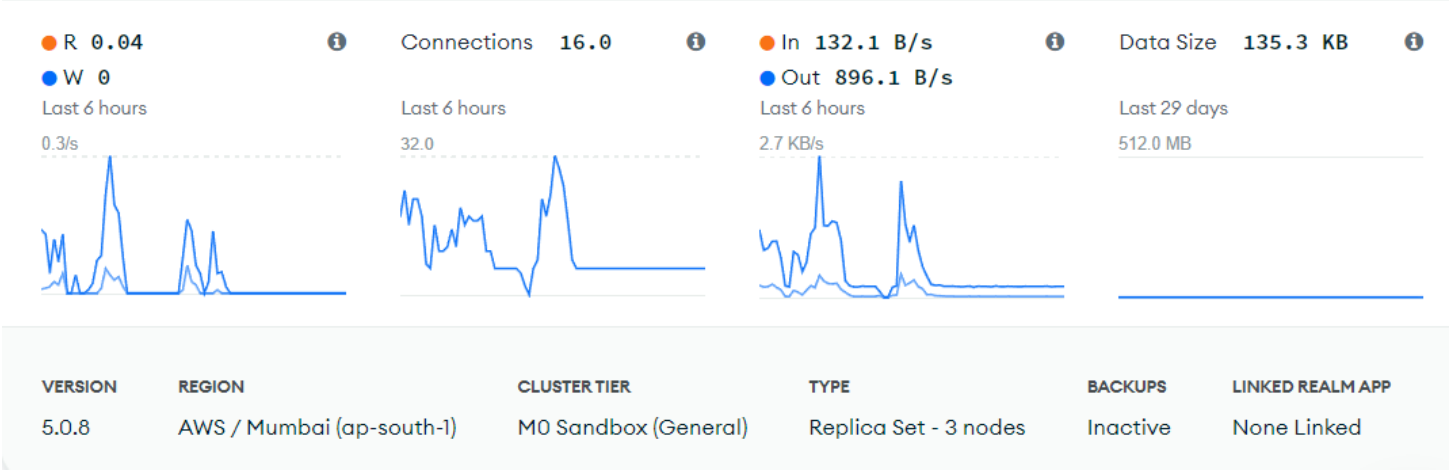
Backend services: Javascript ES6, Solidity ^5.0.3, Core Solidity
User Interface: HTML5, CSS3, EJS framework
No-SQL database: MongoDB

Tools and Services used:

Version Control: Git and Github
CLI: Git bash, Powershell Command Prompt
Code Editor: Visual Studio Code Editor
Dev-Dependencies: Nodemon, .env

3. Results & Observations

Activities on cloud database:



On a smaller scale, the System is able to keep track of components. Also, cloud connectivity enables us to expand the system's capabilities according to our needs.

Activities on Local Blockchain Network:

CURRENT BLOCK	GAS PRICE	GAS LIMIT	HARDFORK	NETWORK ID	RPC SERVER	MINING STATUS
1051	20000000000	6721975	MUIRGLACIER	5777	HTTP://127.0.0.1:7545	AUTOMINING

BLOCK	MINED ON	GAS USED
1051	2022-04-27 14:44:23	43244
1050	2022-04-27 14:44:23	43244
1049	2022-04-27 14:43:57	43288

TX HASH

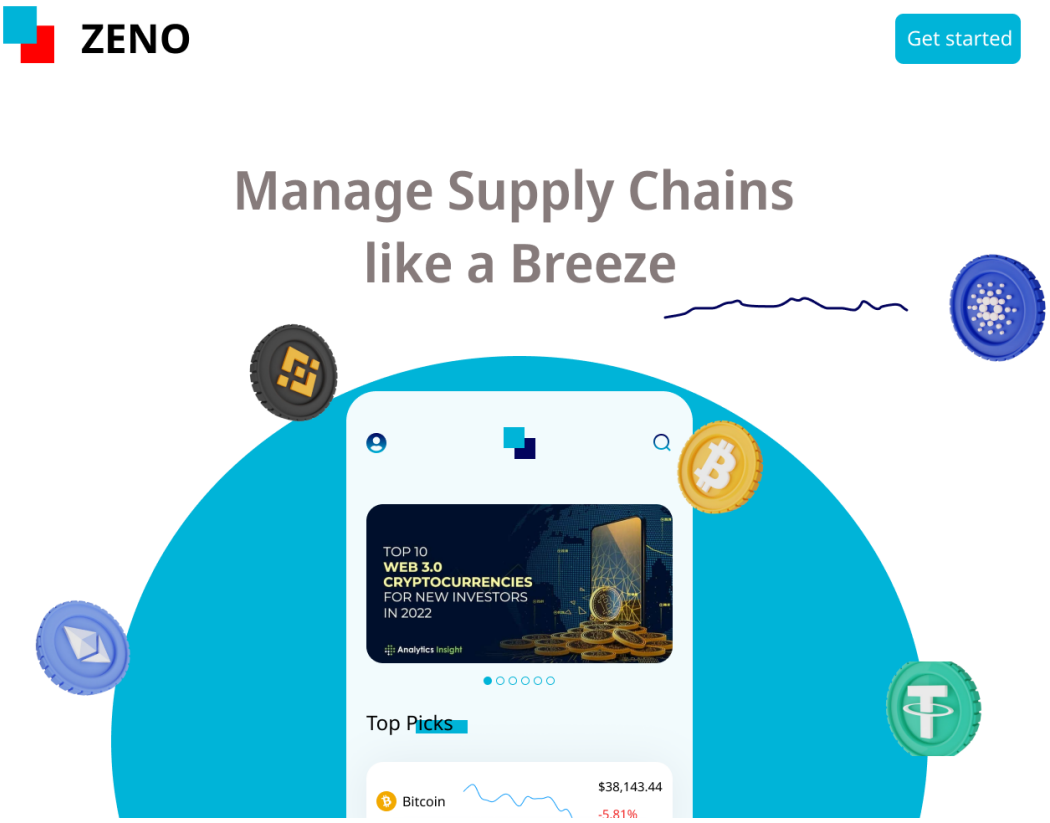
0×d84b27905c976982f27d61e838b3b2193c3b6e4f1f3d1fa6e9ca87d816965437

FROM ADDRESS	TO CONTRACT ADDRESS	GAS USED	VALUE
0×535ec26742feD9Fe9Bd98D851F60B17e621ca68e	0×67bFD6A1c56288f0082eF2B97fe22b598e193918	43244	0

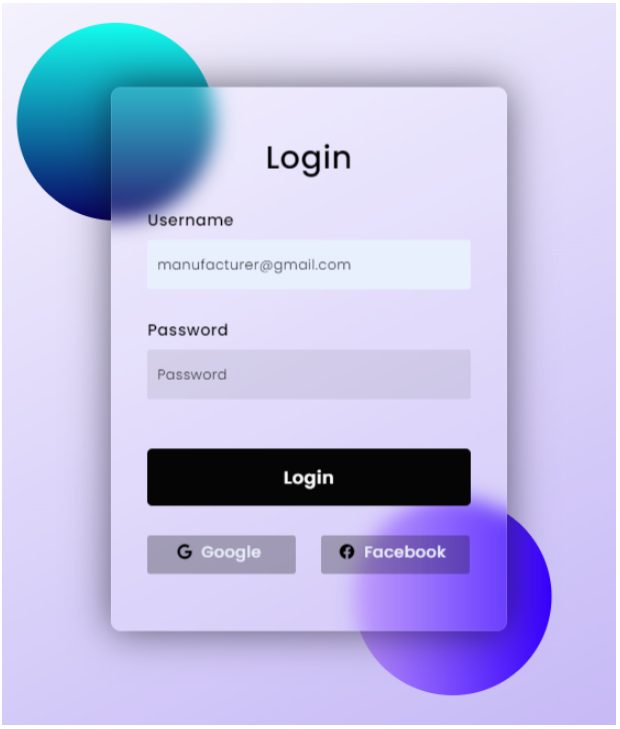
- Local blockchain network registers ledger entry, whenever a transaction happens between two involving. It stores transaction HASH and senders/recipient contract addresses.
- Chain integrity data is stored with every block and provides the basis for immutability (making the data tamper evident).
- In the body of the block are records of each of the transactions: Who is sending it, how much they are sending, where it's going and the fee they paid.
- To maximise the value of using a blockchain to build trust – while maintaining commercial privacy – We have implemented the following solution:

  Share data privately between counterparties and keep records that a transaction occurred and verifiable proof of what was sent and received. Without getting overly technical, it is possible to store a fingerprint of the data (hash) without storing the data itself. This fingerprint can be written into the ledger with a timestamp and sender and a recipient if there is ever a dispute, either party can check the records.

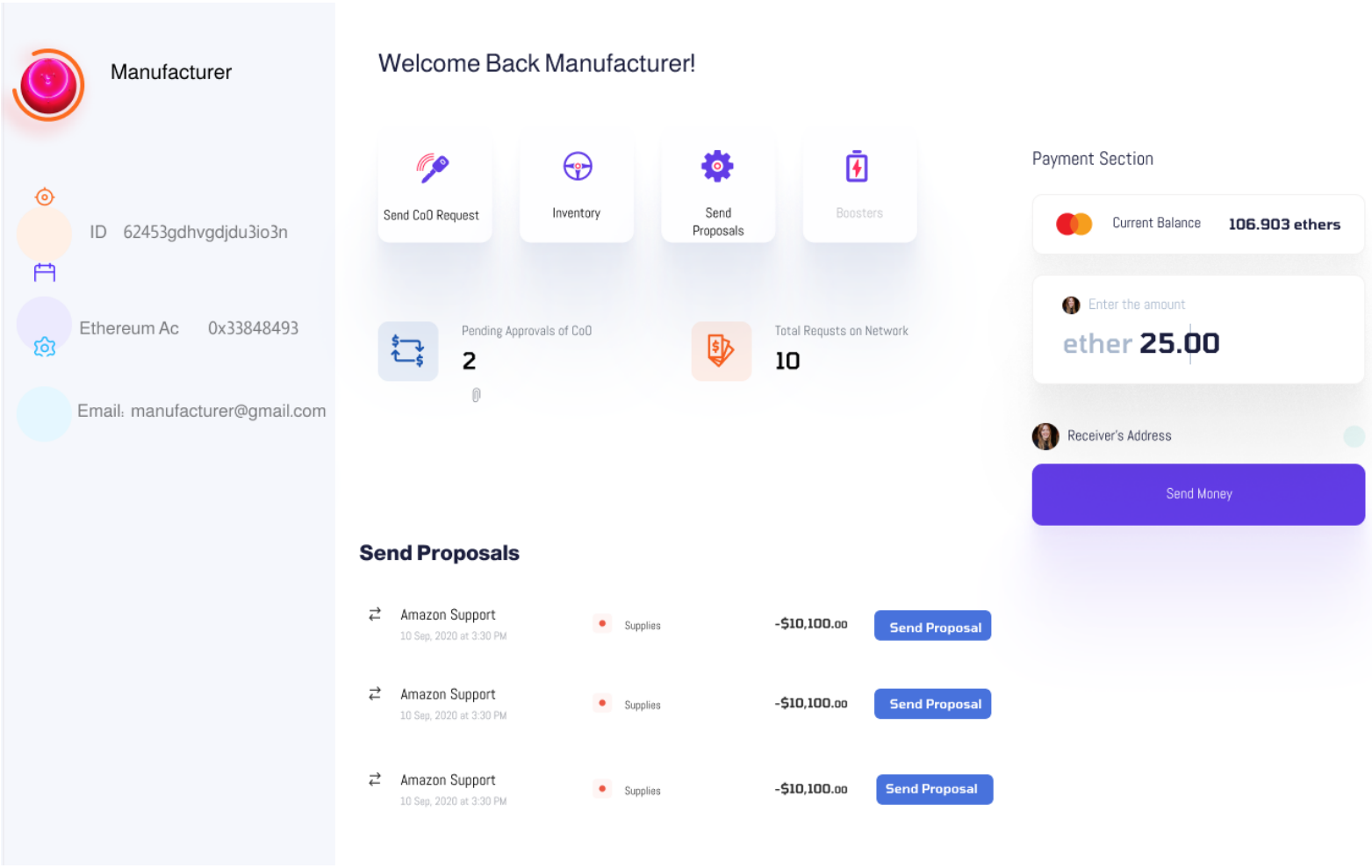
5. Module-wise Implementation Screenshots



Authentication and authorization:



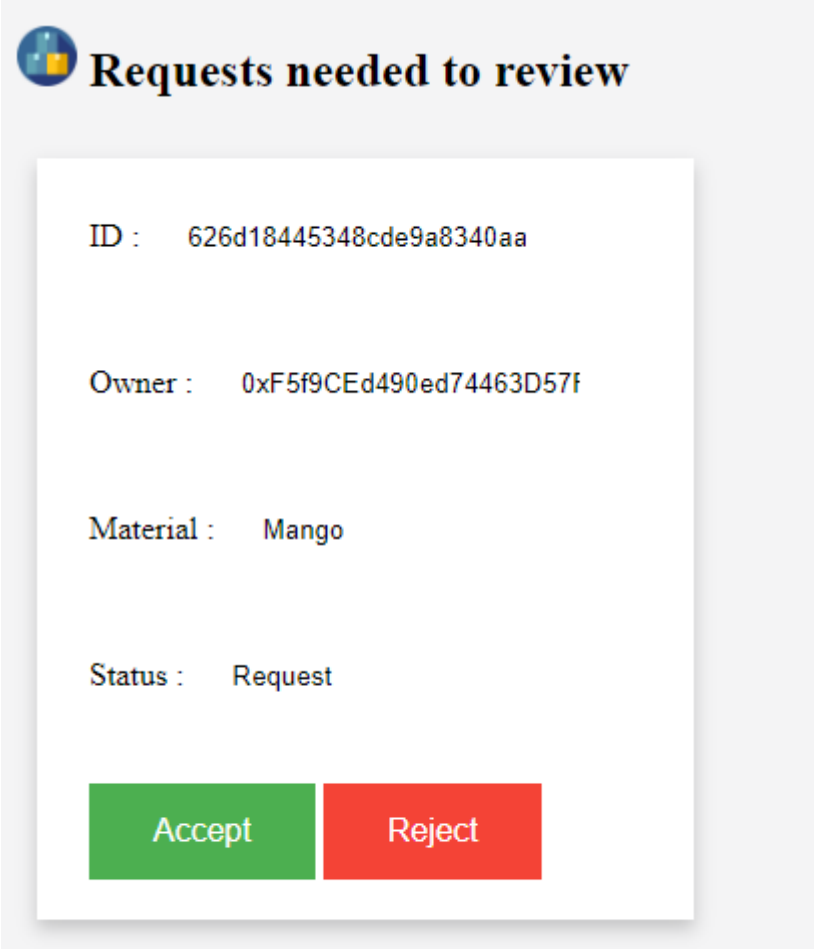
Manufacturer Panel:



The Manufacturer can perform the following operations:

1. Send Certificate of Origin issuance notice to the DigiChambers with all requirements
2. Manufacturers can access the Raw Material Requests on network
3. Manufacturers can send proposals to the Raw Material Requestor on the network with a certain price amount:
   After approval of the proposal Ether amount is transferred to the Manufacturer Account and the Certificate of Origin Ownership is changed between the two parties.

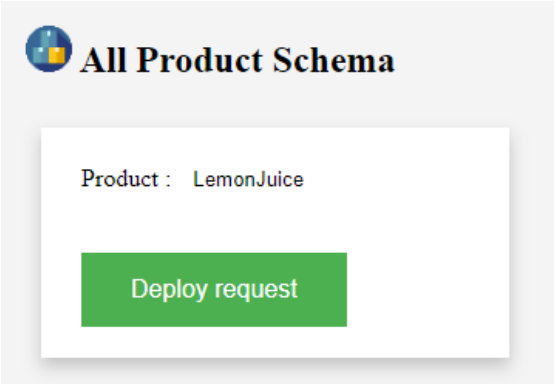
DigiChambers Panel:



1. DIGIChambers have access to all Certificate Origin Requests, they can approve/reject requests according to protocols specified at any stage of the process.
2. It acts as a governing body, to audit and verify the quality of the raw material before any transaction happens within the supply chain.

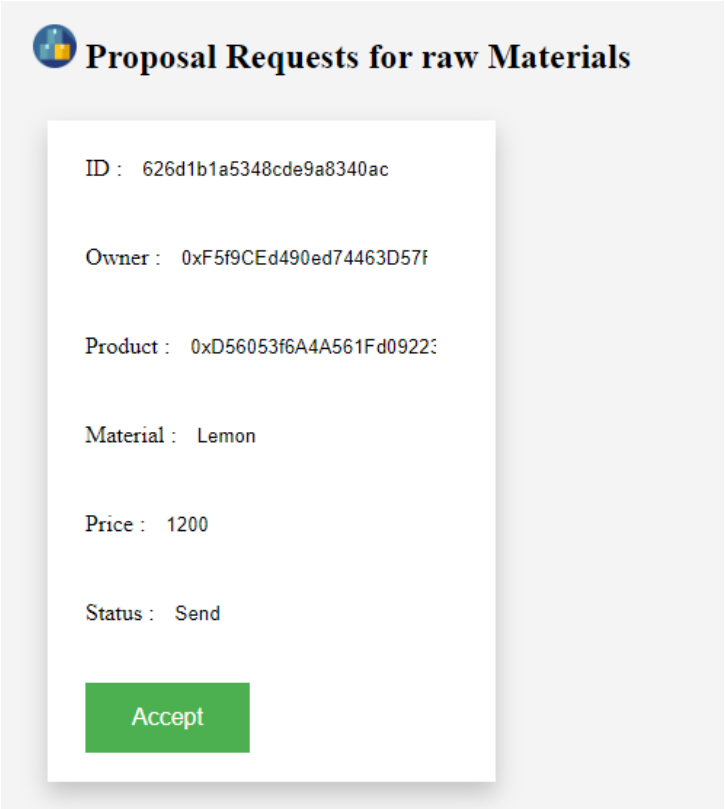
Retailer Panel:

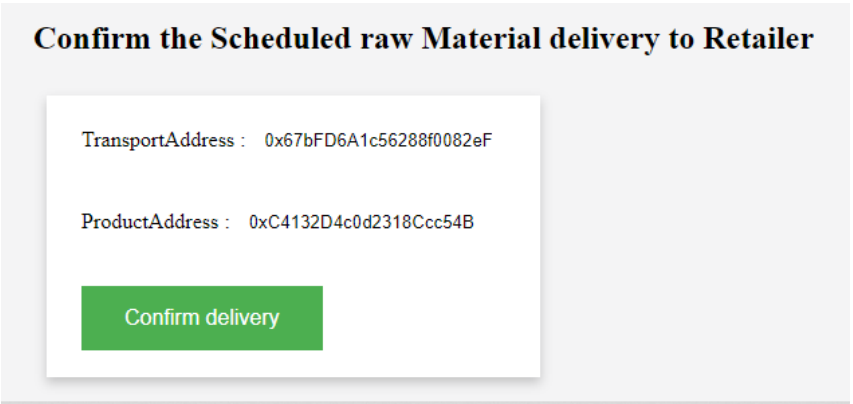
- Retailers can update the product details such as inventory cost, raw material quality, and capacity requirements and stored them as product schema.



- Whenever a product needs to build, retailers can deploy raw material requests on the network with all requirements.

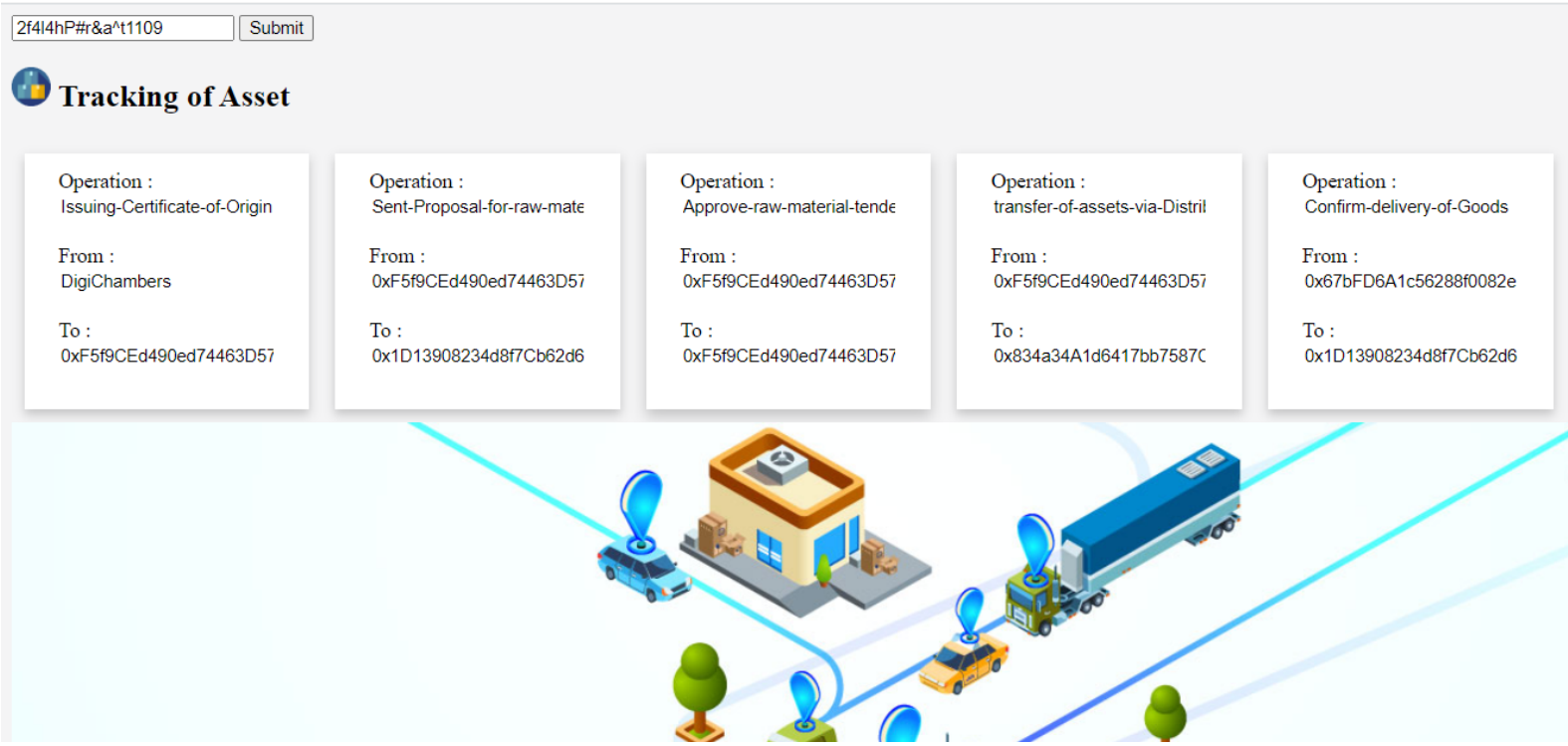
- Retailers can choose from a number of proposals from the manufacturer network, after approval a transfer of ownership takes place. A transport is placed after approval to the distributor network.





- After confirmation of delivery, raw materials are transferred into retailers' inventory and funds are transferred from senders to recipient's accounts.

Asset Tracking Portal:



All the Movements of Assets are being tracked down, at can be detected and analysed at the moment of time, to get the most possible accurate location and state of assets.

It is accessible with a Certificate of Origin ID HASH for each raw material.

5. Future Plan

1. **Diamond Supply Chain Transparency**

   Ensuring that diamonds are ethically sourced is no easy matter. It's exceedingly difficult to trace them from mining and the many handoffs along their supply chain. Integrating blockchain technology into the supply chain to more securely track the origins of its diamonds and provide greater assurance to customers of its responsible practices. It will provide a blockchain-enabled database that supports the independent tracking of every step in the supply chain from the mine operator through each manufacturing step. Blockchain technology facilitates diamond tracking along with all the supporting documentation, including invoices and certification, as it moves through the supply chain, securely storing this chain of custody information. Customers can view information such as the origin of the diamond, the region from which it was sourced and the benefits of mining to that region, the rough carat weight, the lot number, an image of the rough diamond where available, and a 360-degree video of the polished diamond.

2. **Boost drug safety**

   Ensuring the pharmaceutical supply chain works as it should has important ramifications for drug safety, and in turn, consumer safety. The idea is that all drug manufacturers will be responsible for being able to validate that their drugs are authentic from the point of manufacture all the way to the point when they're dispensed to the patient. Currently, drugs are traceable when packed in a box that has a barcode or QR code, but visibility decreases as soon as someone opens and unloads that box because the individual units aren't traceable. an underpinning augmentative layer across the drug supply chain and enabling that unit-level visibility to be traced as they go all the way through. The idea is to give each drug package a unique identifier that can be tracked on the blockchain from the drugmaker to the pharmacy to the consumer and every other stop along the way. That linkage, and being able to see where a drug has been and who touched it and when, effectively makes it very, very difficult for bad counterfeit drugs.

3. Ensure saleable drug returns

Along with more general pharmaceutical supply chain safety, blockchain can help ensure drug returns are legitimate. blockchain technology to create an electronic interoperable system. All prescription medicine returned to distributors must have their unique product identifiers verified with the manufacturers before distributors can resell them. This is to ensure that no one can introduce a counterfeit drug into the supply chain as well as to ensure that the drug is actually coming from the person who bought it. A Blockchain network combines a "look-up directory" accessed through distributed ledger technology with a private messaging network that allows companies to securely request and respond to product identifier verification requests. If the supplier does not confirm if the product is legit, they can't put it into saleable inventory and will have to do further research, which typically involves a call to the drug manufacturer, asking them to confirm whether this is a legit product.

4. Deliver fresher fruit

Blockchain has the potential to provide insight into a company,s sustainability. The idea is, that after growers pick and pack the fruits, they place QR codes onto open crates of fruit. Those codes remain on the crates all the way to the store. Consumers can then scan the QR codes on the individual packages of fruits with their smartphones to see where those berries were grown and even learn about the sustainability practices of the farm. The typical current process is to track the fruit with handwritten paperwork that accompanies each shipment. That process can cause delays in getting fruits clear through customs -- up to four hours for an air shipment and up to two days for a boat shipment. That's not ideal because fresh fruits already have a short shelf life.

6. Conclusion

As consumers demand more transparency and the complexity of supply chains increases, an effective and inexpensive way to trace each material used in the final product is important in building confidence with increasing environmental and socially conscious consumers. We can improve the supply chain by Increasing the visibility of material throughout the entire supply chain; decreasing administrative costs; and authenticating against counterfeit products. Technology is still in early trials in supply chains; the industry is still learning about security, cost, and implications; continued difficulty linking blockchain to physical objects; complexity convincing all stakeholders to adopt blockchain.

Through the project,

- We have tried to digitalise the CoO through the use of Blockchain technology. It is a first step toward the integration of different logistical flows and has great potential to speed up administrative procedures.
- Our team has developed a solution for addressing the issue of raw material accessibility throughout the supply chain. Still thorough academic research is needed to make the process cost-effective.
- Smart Contracts are handling payment transactions between the participating parties, and are immutable & have very low downtime.

Our next steps will be to continue monitoring advancements in blockchain, which have the potential to improve supply chain transparency and offer new opportunities to reduce sourcing risk, decrease administration cost, and improve stakeholder engagement.

As blockchain gains momentum, we should keep observing the players in their industry who have begun experimenting with blockchain. Blockchain benefits greatly from the network effect; once a critical mass gathers in a supply chain, it is easier for others to jump on board and achieve the benefits. Companies should pay attention to other stakeholders in their supply chain and competitors for indication of the timing to develop a blockchain prototype. Current limitations such as Integration concerns, Linking digital to physical, control, security and privacy, and cultural adoption may need to be addressed by much greater academic research. Finally, the system intends to serve as a generic framework, which can be instantiated with any involving part to address questions in the particular domain.

6. References

[1] Building a Transparent Supply Chain by Vishal Gaur and Abhinav Gaiha From the Harward Business Review Magazine (May–June 2020)

[2] What Supply Chain Transparency Really Means by Alexis Bateman and Leonardo Bonanni From the Harward Business Review Magazine (August 2019)

[3] The big challenges for supply chains in 2022 From the World Economic Forum (2022)

[4] Using blockchain to drive supply chain transparency by Stephen Laaper and Joseph Fitzgerald from Deloitte Insider (February 2022)

[5] Five Challenges To Prepare For When Using Blockchain For Supply Chain Operations by Dennis Turpitka Forbes Technology Councils Member (September 2020)

[6] An Improved Network Design of Open Loop Reverse Supply Chain in 2021 International Conference on Automation, Control and Mechatronics for Industry 4.0 (ACMI), 8-9 July 2021, Rajshahi, Bangladesh

[7] Immutable Smart Contracts on Blockchain Technology: Its Benefits and Barriers from 2021 9th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO) Amity University, Noida, India. Sep 3-4, 2021

[8] Enabling Privacy and Traceability in Supply Chains using Blockchain and Zero-Knowledge Proofs from 2020 IEEE International Conference on Blockchain (Blockchain)

[9] A BlockChain based Management System for Detecting Counterfeit Products in Supply Chain: Proceedings of the Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV 2021). IEEE Xplore Part Number: CFP21ONG-ART; 978-0-7381-1183-4

[10] Modelling the Impact of COVID-19 Pandemic on a Hardware Retail Supply Chain from School of Information, Systems and Modelling, FEIT, University of Technology Sydney, Australia

[11] BlockChain Based Inventory Management by QR Code Using Open CV from 2021 International Conference on Computer Communication and Informatics (ICCCI -2021), Jan. 27 – 29, 2021, Coimbatore, INDIA