Implementation of Blockchain in Maritime Logistics Platform

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***Abstract*—Global shipping and trade processes often rely on paperwork, which can lead to problems with tracking and security. We propose using blockchain technology, including smart contracts, to improve these issues. Our proposed system aims to make shipping and trade more secure, transparent, and efficient by implementing blockchain and smart contracts, benefiting all involved parties. We implemented the system by using Truffle and Ganache with Ethereum as the backend, VueJS as the front end, and Web3js for the communications between them. Our work shows that smart contract and blockchain increases the transparency of the transactions between shipping company, terminal agent, vessel owner, customs officer, and delivery agent.**

***Index Terms*—blockchain, smart contracts, maritime logistics, supply chain management**

I. Introduction

Maritime logistics involves various processes such as transportation, storage, loading/unloading, and packaging from suppliers to consumers. However, traditional paper-based documentation used in maritime logistics has limitations in tracking, tracing, and ensuring cargo information. This creates room for fraud and misleading information for ship owners, shippers, and charterers.

With the development of international trade and globalization, logistics is becoming increasingly important worldwide. In the maritime supply chain, however, information asymmetry is a common problem. The chain has low transparency and lacks an effective trust mechanism among the different stakeholders. This has led to the appearance of counterfeit products and product quality scandals, which have harmed the whole maritime supply chain. Although blockchain has been used in many pilot applications, there are still pain points in the maritime industry.

To address these issues, blockchain-based systems offer improved tracking and traceability of relevant data, including cargo information and compulsory certificates. Stakeholders such as shipping companies, vessel owners, terminal operators, and customs officer can upload and publish data to the blockchain by recording this information on a distributed ledger.

Our objective is to establish a comprehensive blockchain platform tailored for maritime logistics, aimed at promoting efficient and secure global trade. By leveraging blockchain technology, we can bolster security and transparency while eliminating the risks associated with paper documentation, such as document loss. All parties involved can directly access documents, with any alterations being fully audited and traceable. Additionally, stakeholders can swiftly access and share digitized trade documents and related events with their supply-chain partners. Furthermore, we can eliminate the expenses tied to printing and physically delivering documents.

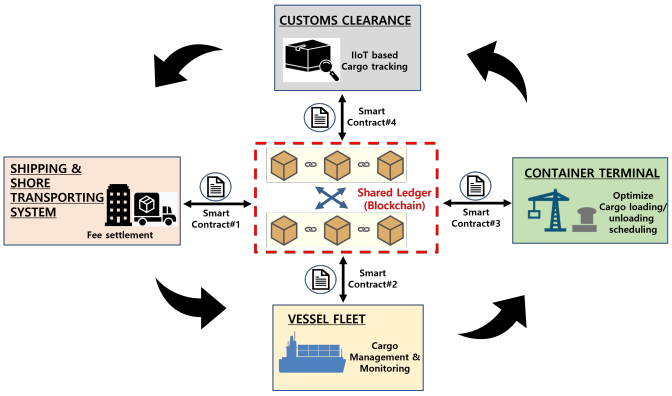

Fig. 1. Proposed coordination between stakeholders.

II. Related Works

Maritime industry's adoption of ICT has resulted in cyber threats such as Maersk's 300 million loss in June 2017 [1]. Global regulations, such as IMO Resolution MSC.428 (98), now require cyber security risk management in safety systems since 2021. IACS, OCIMF, and RIGHTSHIP issued cyber security rules, while BIMCO, DCSA, CIRM, and ENISA published industry guidelines [2].

Previous research [3] has mentioned that applying blockchain technology to the maritime industry is beneficial to address its long service cycles, complex structures, and information heterogeneity. Moreover, there is still open challenges in supply chain and logistics domain, such as counterfeiting, authenticity, provenance tracking and inefficiency [4]. Exclusively, [5] found that blockchain has a great opportunities for a secure supply chain management; reduced anti-counterfeiting problem, improved security, increased trust, competitive advantage, and reduced cost.

Therefore, previous studies lays the foundation for the implementation of our proposed system, which aims to usher in a new era of secure, synchronized, and intelligent maritime supply chain operations while strengthening cooperation among all involved parties.

TABLE I
CONTRACT DETAILS.

Contract	Function
ShippingInformation	getAllCargoInfo getCargoInfo registerCargo updateCargo
ContainerTerminal	getCargoLoadingSchedule getCargoUnloadingSchedule updateCargoLoadingSchedule updateCargoUnloadingSchedule updateCargoScheduleStatus getAllCargoSchedule
VesselFleet	getCurrentLocation getEstimatedTimeOfArrival updateVesselFleetData getVesselFleetData
CustomClearance	getCargoVerification verifyCargo

III. PROPOSED SYSTEM

Our proposed system includes the following key functions:

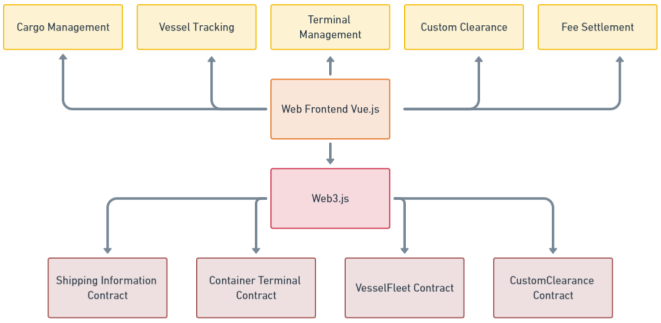

Fig. 2. Functional architecture of the proposed system

1) **Cargo Management**: Admins can register and manage cargo information for shipping companies using user-friendly forms simplify data input for cargo details.
2) **Vessel Data**: Admins handle vessel information, including additions and updates such as real-time vessel data, such as location and ETA.
3) **Terminal Contract**: Admins manage cargo loading and unloading schedules.
4) **Customs Clearance**: Admins verify customs clearance before proceeding to fee settlement.
5) **Fee Settlement**: Admins handle fee payments within the Shore Transport contract.

The functional architecture of the proposed system can be seen in figure 2.

IV. RESULTS

A. Implementation

1) Environment Setup:

- The backend is built using Truffle 5, a framework for Ethereum development, and Ganache with Remix, which provide tools for contract compilation and testing. Contracts development can be found in https://github.com/millatip/maritime-logistics/tree/master
- The frontend is developed using Vue.js 2, a JavaScript framework for building user interfaces. Web interface can be found in https://github.com/millatip/shiplog-admin

2) Smart contract development and testing:

- Once the environment and project are set up, we design the smart contract based on maritime logistics requirements.
- We utilize Visual Studio Code to write the solidity code to implement the functionalities we define for the smart contracts. We use solidity compiler 0.8.20. One key function we've implemented is *settleFee*, which is part of the *ShoreTransport* contract. This function is responsible for settling the fee associated with a particular cargo. Before proceeding with the fee settlement, the function checks if the cargo is verified by calling the *getCargoVerification* method from the *CustomClearance* contract. Only after cargo is verified by the customs officer, the fee settlement can be proceed. Table I summarizes the developed contracts and the functions inside.

```
// Function to settle the fee for a cargo
function settleFee(string memory _cargoID)
     public {
    // Check if cargo is verified in
        CustomClearance contract
    (bool isVerified) = customClearance.
        getCargoVerification(_cargoID);
    require(isVerified, "Cargo is not
        verified");

    Transaction storage transaction =
        transactions[_cargoID];
    require(!transaction.isSettled, "Fee
        already settled");

    transaction.isSettled = true;
    emit FeeSettled(_cargoID, transaction.
        amount);
}
```

- We use 'truffle test' for unit testing.
- We employ the Remix extension to deploy the smart contract onto the test network known as Ganache.
- We utilize Ganache desktop to provide a visual representation of the transactions being executed involving the contract.

3) Web dApp Development:

- We have developed the user interface using Vue.js 2. We opted for Vue.js as our frontend framework due to its characteristics of being lightweight, progressive, and highly reactive.
- We employed the web3.js version 1.10 to establish a connection between our web interface and the smart contracts that we have deployed on the blockchain.

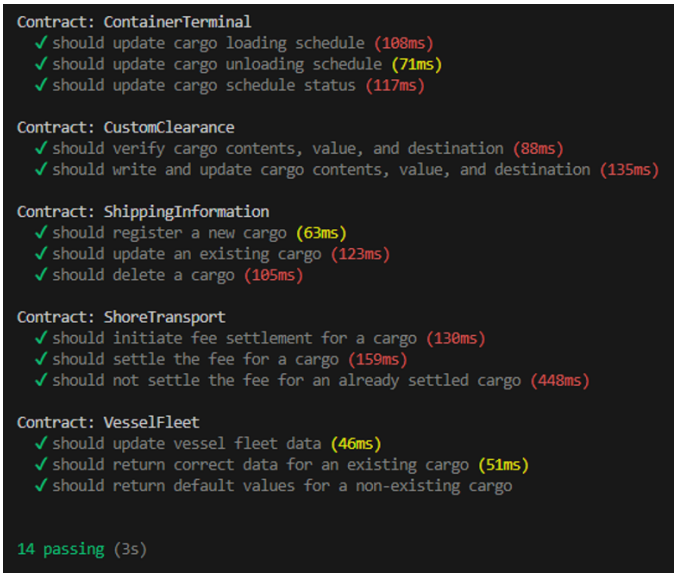

Fig. 3. Unit test result of the contracts.

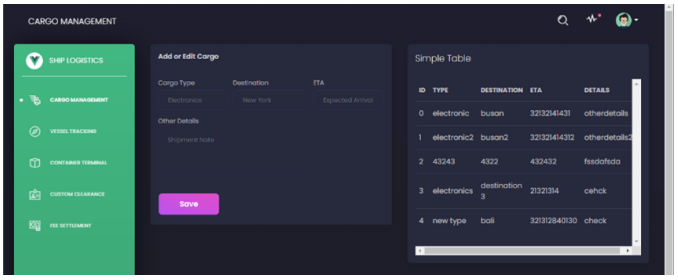

Fig. 4. dApp user interface

4) Integration and testing:

- We utilize Ganache desktop to observe the comprehensive transactions activity taking place within the web interface.

B. Results

Using the blockchain as the backend part of the platform increases the transparency of the transactions. Several users from different sectors in the part of maritime logistic; the shipping company, terminal agent, vessel controller, custom clearance agent, and delivery agent.

V. Conclusion

Our project's main goal is to bring blockchain technology to the world of maritime logistics. We started by designing smart contracts for various tasks in this field, like managing cargo, tracking ships, and handling fees.

To make this happen, we used tools called Truffle and Ganache to set up the blockchain, and Vue.js for the website's front-end. We also used web3.js to connect the website with the smart contracts on the blockchain. We ended up with four contracts: "Shipping Information", "Container Terminal", "VesselFleet", and "Custom Clearance." as has been explained in the Table I. We also developed dApp for admins to manage cargo, track ships, handle customs clearance, and settle the payment.

Our project shows how blockchain can make things more transparent in maritime logistic system. Moreover, in the maritime logistic scenario where the integration of each sector is crucial and has issues of trustworthiness, blockchain can be an answer. This approach will foster greater trust among stakeholders, streamline processes, reduce the risk of fraud, and ultimately enhance the efficiency and security of the entire maritime logistics ecosystem.

In this research, we implemented all the features in one web dApp without the user leveling and user privilege separation. While this is considered as an easier approach, such features should be implemented in the real deployment to improve security.

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