



Logistics Shipping Based Blockchain Using Smart Contracts

Mallellu Sai Prashanth¹(✉), Ramesh Karnati¹, Muni Sekhar Velpuru²,
and H. Venkateshwara Reddy²

¹ Department of Computer Science and Engineering, Vardhaman College of Engineering,
Hyderabad, India

saiprashanth08@ieee.org, ramesh.krnt@vardhaman.org

² Department of Information Technology, Vardhaman College of Engineering, Hyderabad, India
{munisek,h.venkateswarareddy}@vardhaman.org

Abstract. The logistics industry is a vital component of the global economy, but it still faces several challenges, including inefficient processes, lack of transparency, and high costs due to intermediaries. Blockchain technology has the potential to address these challenges by providing a decentralized and transparent platform that can automate and streamline logistics processes through smart contracts. This research paper presents a study on Logistics shipping based on blockchain using smart contracts in Solidity language. The paper discusses the challenges in the logistics industry and the potential of blockchain technology to solve them. It then presents a Smart Contract for Logistics shipping, including the required variables, a struct for shipments, a mapping to hold the shipments, events for shipment creation and delivery, and functions to create a new shipment, mark a shipment as delivered, and get the shipment details. The paper also discusses the benefits and limitations of the proposed solution and compares it with existing logistics systems. It concludes that the proposed solution can provide a secure, transparent, and efficient platform for logistics shipping that can eliminate intermediaries, reduce costs, and improve the overall logistics ecosystem. Overall, this research paper provides insights into the potential of blockchain technology for logistics shipping and presents a practical solution that can be implemented in real-world scenarios. It also highlights the need for further research and development to optimize the solution and address any potential challenges in its implementation.

Keywords: Block Chain · Trust · Reputation · social control and privacy

1 Introduction

The administration of goods and services from the point of origin to the point of consumption is referred to as logistics shipping. Planning, coordinating, and carrying out transportation, warehousing, and distribution operations are all part of this process. Delivering goods in a timely, effective, and economical manner to their destination is the aim of logistics shipping [1]. Several processes are included in logistics shipping, such

as route planning and optimization, inventory control, freight forwarding, customs clearance, and delivery synchronisation. Effective communication and cooperation between the different parties involved, including the manufacturer, the carrier, the warehouse, and the customer, are essential to the success of logistics shipping [2]. The effectiveness and efficiency of logistics shipping have significantly increased thanks to technological advancements including the usage of GPS tracking, EDI, and transportation management systems (TMS). However, the sector still has to deal with issues including growing fuel costs, more stringent government regulations, and shifting consumer demand [3].

Importance of Logistics Shipping: Logistics shipping is important because it ensures that products are available when and where they are required, which is essential to corporate success. Effective logistics shipping may boost competitiveness, lower costs, and raise customer happiness.

Key Logistics Shipping Activities: Route planning and management, inventory management, logistics services, customs checks, and delivery coordination are some of the tasks involved in logistics shipping. Since the numerous parties participating in these activities are interconnected, efficient communication and teamwork are required.

Challenges Faced by the Industry: The logistics shipping sector still has to deal with issues like growing fuel costs, more stringent government regulations, and shifting consumer demand. Businesses must be flexible and adaptable in order to meet these obstacles, as well as constantly enhance their systems and procedures.

Route Planning and Optimization are Crucial: Route planning and optimization are essential elements of logistics shipping because they assist in identifying the most effective and economical method of moving products from one location to another. When designing and optimising routes, variables including distance, time, cost, and capacity are taken into account.

Inventory Control: Logistics shipping includes inventory management, which is crucial for ensuring that the correct goods are available at the right times in the right quantities. Effective inventory management may lower costs, increase customer happiness, and reduce waste.

Transport Planning: Logistics firms that specialise in organising and managing the delivery of products from one location to another offer freight forwarding as a service. Between the shipper and the carrier, freight forwarders serve as a middleman and are in charge of finding the most economical and effective modes of transportation.

Coordination of Delivery: The last step in the logistics shipping process is delivery coordination, which entails making sure that products are delivered to the client quickly and effectively. Utilizing dependable and effective delivery methods, as well as excellent communication and collaboration between the carrier, the warehouse, and the customer, is necessary for delivery coordination.

In this paper we propose Logistics shipping based blockchain using smart contracts. Smart contracts and block chain technology have the ability to completely transform the logistics and shipping sector. A decentralised, secure, and open technology called block chain makes it possible to build a shared digital ledger. Self-executing contracts,

or “smart contracts,” are agreements that automatically carry out the provisions of a contract between two parties [4]. The logistics shipping sector can gain a lot from using blockchain and smart contracts, including higher efficiency, lower costs, and improved transparency. Due to the fact that all transactions are recorded in a tamper-proof ledger, the usage of block chain technology can help to reduce errors and fraud. Smart contracts can also automate information flow and cut down on the time and expense of manual processes [5].

2 Related Work

Blockchain Technology

Blockchain is a digital ledger that is not centralised and tracks transactions among a number of machines. It was initially developed to serve as the backbone of the cryptocurrency Bitcoin, but it has since discovered a wide range of potential uses in a number of different sectors, including finance, healthcare, supply chain management, and more. A blockchain’s decentralised nature, or the fact that it runs on a peer-to-peer network and is not under the control of a single institution, is its primary characteristic. A secure and transparent history of all transactions on the network is created by the recording of transactions in blocks and linking them together in a chain [9].

The use of cryptography by blockchain technology to guarantee the security and immutability of transactions is another crucial feature. A block’s contents are irreversible once it is added to the blockchain and cannot be changed or removed. Overall, blockchain has the potential to revolutionise numerous industries by offering decentralised, secure, and transparent solutions to a wide range of issues [10].

The inability to change or remove data after it has been stored on a blockchain makes the record of transactions safe and impenetrable. This is accomplished by utilising cryptographic methods, which guarantee the accuracy of the data on the blockchain [11].

Greater transparency is made possible by blockchain technology because every user of the network has access to the same data. As a result, there can be more responsibility and trust in transactions because all users have access to the data on the blockchain [12].

There are two types of blockchains: public and private. Public blockchains, like the Ethereum and Bitcoin networks, are accessible to everyone and permit participation from anybody. Contrarily, private blockchains are only accessible to a select group of users and are frequently utilised by businesses for internal purposes [13].

By enhancing security, transparency, and efficiency across a wide range of businesses, blockchain technology has the potential to transform many of them. Although the technology is still in its infancy, its potential for innovation is enormous, and it is quite likely to play a big part in the growth of numerous industries in the future [14].

Ethereum

With the intention of developing into a decentralised platform for creating and utilising decentralised apps, Ethereum is a blockchain-based platform that was presented in 2015. (dApps). Anyone can access the source code and build on it because it was developed as an open-source platform [15].

Because it enables developers to write self-executing contracts with the details of the agreement between the buyer and seller being directly encoded into lines of code, Ethereum is frequently referred to as a “smart contract platform.” As a result, sophisticated decentralised applications that go beyond straightforward value exchanges can be created [16].

Ether (ETH), the native cryptocurrency of the Ethereum platform, is one of its distinguishing characteristics. It is used to fund network transactions and computational services. Decentralized autonomous organisations (DAOs), which are managed through code rather than by a central authority, can also be created on the Ethereum network [17].

With a strong developer community and an expanding ecosystem of decentralised applications (dApps), tools, and services, Ethereum has developed into one of the biggest and most well-known blockchain platforms. New innovations and updates are always being added to the platform to increase its functionality, scalability, and security [18].

The implementation of the project is done in Ethereum online compiler [remix.ethereum.org]. A web-based Innovative Development Environment (IDE) called Remix.ethereum.org is used to create, test, and deploy smart contracts on the Ethereum network. It gives programmers a platform to create, test, and deploy smart contracts using Solidity, the main programming language for Ethereum [19].

Developers don't need to install any software or tools while using Remix to build, test, and publish their smart contracts from a web browser. Developers may write code more easily on the platform thanks to the editor's syntax highlighting and autocompletion features. Additionally, Remix has a built-in debugger that enables developers to test their contracts, find any problems, and resolve them.

Use of Remix is unrestricted and open source. It is one of the most extensively used platforms for creating and implementing Ethereum smart contracts and is managed by the Ethereum Foundation.

Smart Contracts

In smart contracts, the details of the agreement between the buyer and seller are directly encoded into lines of code. These contracts self-execute. They are made to automatically enforce the terms of a contract without the assistance of middlemen like attorneys or brokers [20].

Blockchain technology, which offers a secure and open ledger for recording and tracking transactions, is generally used to build smart contracts. As a result, the contract's terms are automatically carried out and upheld without further action from the parties.

Smart contracts' capacity to lower costs and boost efficiency by doing away with the need for middlemen is one of its main advantages. Due to the fact that the contract's terms are encoded into the blockchain and are therefore open to audit and verification, they also provide greater security and confidence.

Supply chain management, transactions in real estate financial services, and insurance are just a few of the many potential uses for smart contracts. Without requiring user involvement or running the risk of fraud, a smart contract may be used, for instance, to automatically release payment for a shipment of goods once the delivery has been verified.

Overall, smart contracts are an exciting new technology that could completely change how contracts are negotiated and carried out, lowering costs, boosting productivity, and boosting security and trust.

Smart Logistics Shipping

In order to ensure that items are delivered to clients on time and for the lowest possible price, smart logistics aims to build a more intelligent, connected, and efficient supply chain. Smart logistics uses cutting-edge technologies to automate and improve crucial procedures including inventory control, delivery tracking, and transportation planning. For instance, utilising IoT devices to track shipments in real-time can increase supply chain visibility and let logistics managers spot and fix bottlenecks or delays faster.

Although smart logistics is still in its infancy, it has the potential to completely transform the logistics sector by cutting costs, raising service levels, and opening up new business strategies and revenue streams. Companies can build an agile, responsive, and efficient supply chain that can better meet customer expectations and help them remain ahead of the competition by adopting smart logistics.

A term used to describe the application of cutting-edge technology, including blockchain, the Internet of Things (IoT), and artificial intelligence (AI), to enhance the effectiveness and transparency of the logistics and shipping sector.

Smart logistics shipping strives to address industry issues like high operational costs, protracted processing delays, and a lack of visibility and transparency throughout the supply chain by utilising these technologies.

Blockchain technology, for instance, can be used to build a shared and secure ledger of all shipments and transactions, giving everyone in the supply chain instant access to the same data. As a result, there may be a lower chance of fraud and mistakes, and there may be better communication and coordination between the various supply chain participants.

Although smart logistics shipping is still in its infancy, it has the potential to revolutionise the market by increasing productivity, bringing down prices, and improving consumer experiences. Additionally, it gives a chance to develop fresh company ideas and sources of income as well as to improve sustainability by lowering the waste and emissions produced by shipping and logistics.

3 Proposed Method

The logistics shipping based blockchain using smart contracts is implemented in ethereum online compiler which is remix.ethereum.org and it is implemented in solidity. Logistics shipping based blockchain using smart contracts is implemented by the following algorithm (Fig. 1).

Algorithm for Logistics shipping based blockchain shipping using smart contracts

1. Declare the required variables:
 - address sender
 - address receiver
 - uint256 shipmentId
 - uint256 weight
 - uint256 price
 - uint256 deliveryTime
2. Define the Smart Contract:


```
contract Logistics {
}

```
3. Declare the Struct for shipments:


```
struct Shipment {
address sender; ad-
dress receiver;
uint256 shipmentId;
uint256 weight;
uint256 price;
uint256 deliveryTime;
bool delivered;
}

```
4. Declare the mapping to hold the shipments:


```
mapping(uint256 => Shipment) shipments;

```
5. Declare the events for shipment creation and delivery:


```
event ShipmentCreated(address sender, address receiver, uint256 shipmentId, uint256 weight, uint256
price, uint256 deliveryTime);
event ShipmentDelivered(uint256 shipmentId);

```
6. Define the function to create a new shipment:


```
function createShipment(address _sender, address _receiver, uint256 _shipmentId, uint256 _weight,
uint256 _price, uint256 _deliveryTime) public {
Shipment storage newShipment = shipments[_shipmentId];
newShipment.sender = _sender;
newShipment.receiver = _receiver; newShip-
ment.shipmentId = _shipmentId; newShip-
ment.weight = _weight; newShipment.price =
_price; newShipment.deliveryTime = _de-
liveryTime;newShipment.delivered = false;
emit ShipmentCreated(_sender, _receiver, _shipmentId, _weight, _price, _deliveryTime);
}

```
7. Define the function to mark a shipment as delivered:


```
function markShipmentDelivered(uint256 _shipmentId) public {
Shipment storage deliveredShipment = shipments[_shipmentId];
deliveredShipment.delivered = true;
emit ShipmentDelivered(_shipmentId);
}

```
8. Define the function to get the shipment details:


```
function getShipmentDetails(uint256 _shipmentId) public view returns (address, address, uint256,
uint256, uint256, uint256, bool) {
Shipment storage requestedShipment = shipments[_shipmentId];

return (requestedShipment.sender, requestedShipment.receiver, requestedShipment.shipmentId,request-
edShipment.weight, requestedShipment.price, requestedShipment.deliveryTime,
requestedShipment.delivered);
}

```

The following elements make up the process model of a smart contract-based blockchain system for logistics and shipping:

Shipment Initiation: The procedure begins when the shipper submits a request for a shipment, including information about the kind of products, origin and destination,

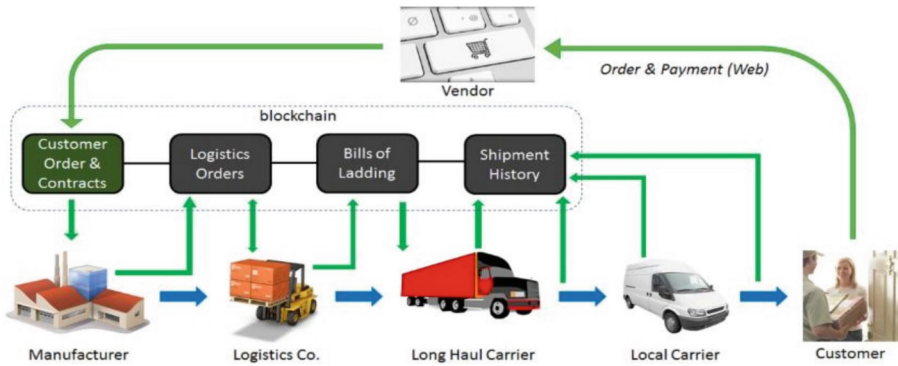


Fig. 1. Process model of Logistics shipping based blockchain using smart contracts

and anticipated delivery date. The `OrderItem()` method id used to place an order of a particular item. After placing the order the `OrderItem()` method returns the uniqueid. In this particular application when the `OrderItem()` method is invoked we can place order by typing the item id and item name. The uniqueid on decoding it later gives the information about the order and helps in package tracking or package mapping which gives overall details of the order such as status of the order. The `OrderItem()` method also displays the confirmation message to the user as “Your package is ordered and is under process”. The uniqueid is generated by using the SHA-256 algorithm. Hence the security of the order is increased and also increases the efficiency of logistics shipping.

A cryptographic hash function called SHA-256 is employed for safe data transfer and data security. It is a one-way function that produces a fixed-size output from an input of arbitrary length (256 bits). For a specific input, the output is distinct, and even a minor modification in the input causes an entirely different outcome. As a result, SHA-256 is a trustworthy instrument for data integrity and protection since it ensures that the data was not altered during transmission.

Smart Contract Development

On the blockchain network, a smart contract is subsequently made that specifies the details of the shipping, including the delivery date, the terms of payment, and any applicable laws. Programming languages compatible with the blockchain platform, such as Solidity for Ethereum, are used to create smart contracts. The blockchain network is subsequently used to install the smart contract code, which then becomes a permanent part of the ledger. In order to ensure the efficient and secure execution of transactions on the blockchain network, smart Contract Creation is a crucial component in the creation of blockchain-based applications.

Understanding the blockchain technology and the programming languages used to create the contracts is necessary for creating smart contracts. A complete comprehension of the use case and the circumstances that lead to the execution of the contract are also necessary, in addition to a clear understanding of the terms of the parties’ agreement.

We created a smart contract named Logistics which contains the six functions inside it. They are OrderItem(), CancelOrder(), ManageCarriers(), Carrier1Report(), Carrier2Report(), Carrier3Report() (Fig. 2).

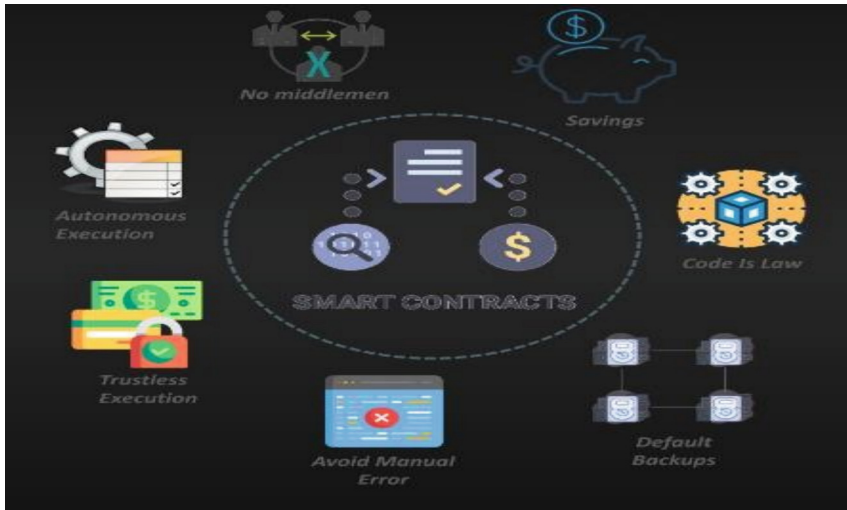


Fig. 2. Smart contract creation for Logistics shipping based blockchain using smart contracts

Carrier Acceptance

An important step in the shipping procedure is the carrier's acceptance, which signifies that the carrier has consented to assume custody of the goods and carry them to their destination. A bill of lading, which serves as a receipt for the goods and proves that the carrier has agreed to deliver them, is typically issued to formalise the acceptance of the items by the carrier.

Smart contracts can be used to automatically accept from Carrier. A smart contract that specifies the terms and circumstances of the shipment can be executed to force the carrier to accept the shipment. This can involve the date of delivery, the path used, the kind of cargo being delivered, and the cost of the services rendered.

Once the smart contract has been carried out, it is added to the blockchain network's permanent ledger, creating an unchangeable and secure record of the carrier's acceptance. As a result, the shipping process is more transparent and efficient as all stakeholders have access to the same data and can follow the shipment in real-time.

The automation of Acceptance by Carrier—a crucial stage in the shipping process—through smart contracts can offer a safe and effective way to manage logistics shipping on a blockchain network.

Package Tracking

Package tracking is the process of keeping track of a package's route from its origin to its destination. A tracking number or code, which is given to the product when it is

dispatched, is often used to achieve this. With the help of this number, you may check the package's location, status, and delivery status online or using a mobile app.

Using blockchain technology can substantially improve shipment tracking. On the blockchain network, every stage of the shipping process, including pickup, delivery, and transportation, may be documented as a transaction. This produces a safe, transparent, and impenetrable record of the package's travels that is simple for all parties to access and track.

The tracking of packages can also be automated using smart contracts. For instance, a smart contract can be activated to cause an update to the package's status on the blockchain when it is picked up. This can contain the pickup date and time, the precise location, and any other pertinent details.

Additionally, smart contracts can be used to automatically trigger actions, such as sending messages to the sender or recipient in the event of problems or delays with the cargo. Since everyone involved has access to the same information and can follow the item in real-time, this can considerably increase the efficiency and transparency of the package tracking process.

Package tracking is a crucial component of logistics shipping, and leveraging smart contracts on a blockchain network to implement it can offer a safe, open, and effective way to manage the shipping process.

Delivery

Shipping in Logistics The last phase of the shipping process, when the items are transferred from the carrier to the recipient, is referred to as shipping-based blockchain employing smart contracts. The carrier, the recipient, and any other parties engaged in the shipment process must work together during this crucial stage.

With the use of smart contracts and logistics shipping based blockchain, the delivery procedure can be significantly enhanced. By establishing the terms and circumstances of the delivery, a smart contract can be utilised to automate the delivery process. This can include the time of delivery, who the recipient is, and any other pertinent details.

The delivery process can be significantly enhanced by employing smart contracts in logistics shipping based blockchain. The terms and conditions of the shipment can be specified in a smart contract, which can then be utilised to automate the delivery procedure. The recipient's name, the delivery date, and any other pertinent information can all be included here.

An immutable and secure record of the delivery process is provided once the smart contract has been carried out and has been added to the blockchain network's permanent ledger. Since everyone involved has access to the same information and can follow the shipment in real-time, this increases transparency and efficiency in the delivery process.

Another smart contract that specifies the delivery's terms and conditions can be executed, requiring the recipient to accept the delivery. This can cover the delivery confirmation, the state of the products, and any other pertinent details.

Delivery is a crucial step in the logistics shipping process, and automating it with smart contracts can give logistics shipping on a blockchain network a secure, open, and effective management system.

Record Keeping

The usage of blockchain technology significantly improves record keeping and is based on logistics shipping and Smart Contracts. Each shipment's transactions, including pick-up, delivery, and transportation, are tracked as blocks on the blockchain network. This produces a safe, open, and impenetrable record of the shipment that all stakeholders can easily view and trace.

Additionally, record keeping procedures can be automated using smart contracts. For instance, a smart contract can be activated to cause an update to the shipment's blockchain record when the package is picked up. This can contain the pickup date and time, the precise location, and any other pertinent details. This can assist in ensuring that the shipment's information is accurate and current throughout the shipping procedure (Fig. 3).



Fig. 3. Blockchain based supply chain model classifiers

Dispute Resolution

The process of settling disputes or differences that may develop between parties throughout the course of a transaction is referred to as dispute resolution. Disputes may occur in the context of Logistics Shipping based Blockchain using Smart Contracts for a number of reasons, including harmed items during delivery, improper or delayed delivery, or problems with payment.

A secure, transparent, and impenetrable record of the resolution can be created by recording the conclusion of a dispute on the blockchain network once it has been settled. As all parties involved have access to the same information and can use the resolution of earlier disagreements as a guide, this can be helpful in the event of future problems.

Any transaction, including logistics shipment, must include dispute resolution. The use of blockchain method and smart contracts in logistic support shipping can offer a safe, open, and effective way to settle disputes, cutting down on the time and expense of using conventional dispute resolution procedures.

4 Result Analysis

Smart Contract for Logistics shipping based on blockchain using Solidity language. It includes the required variables, a struct for shipments, a mapping to hold the shipments, events for shipment creation and delivery, and functions to create a new shipment, mark a shipment as delivered, and get the shipment details.

The Smart Contract can be used to create a decentralized platform for logistics shipping that can ensure transparency, security, and efficiency by eliminating intermediaries and automating the shipment process through smart contracts. It can also be integrated with other blockchain-based systems, such as supply chain management, to create a comprehensive logistics ecosystem (Figs. 4, 5, 6, 7, 8, 9 and 10).

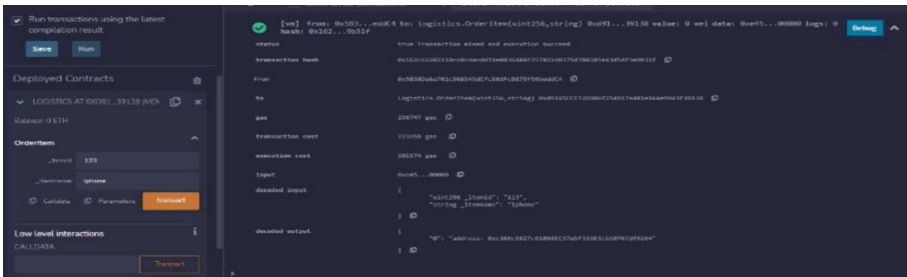


Fig. 4. Ordering an Item from Ethereum

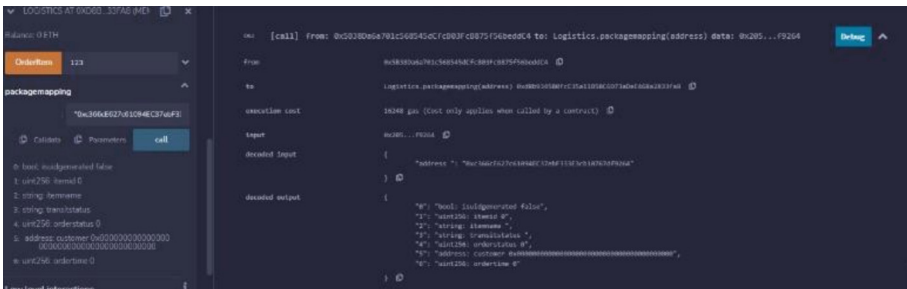


Fig. 5. Sample of Package Mapping in smart contracts

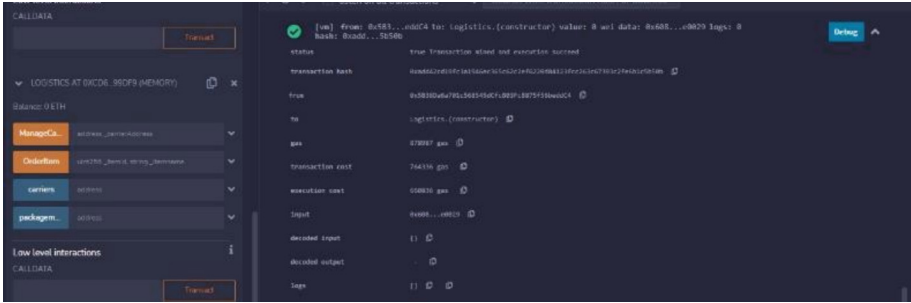


Fig. 6. Manage Carriers Operation, Generating decoded O/P

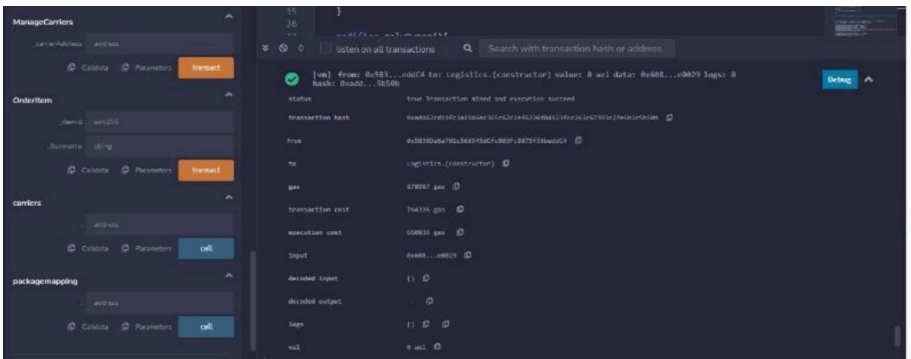


Fig. 7. Generating the Carriers Operations

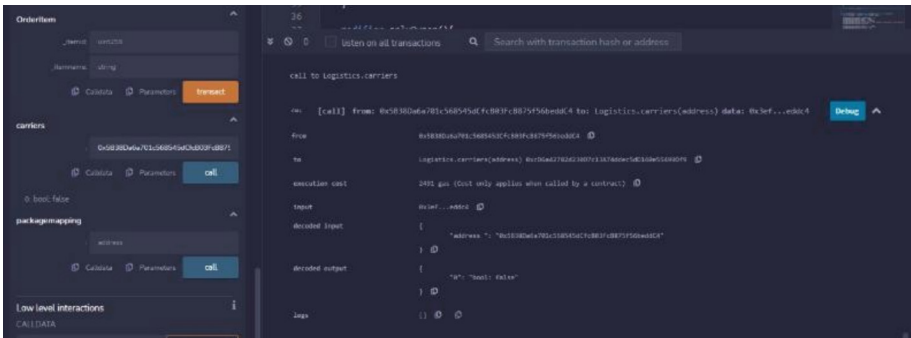


Fig. 8. Generating the Package Mapping

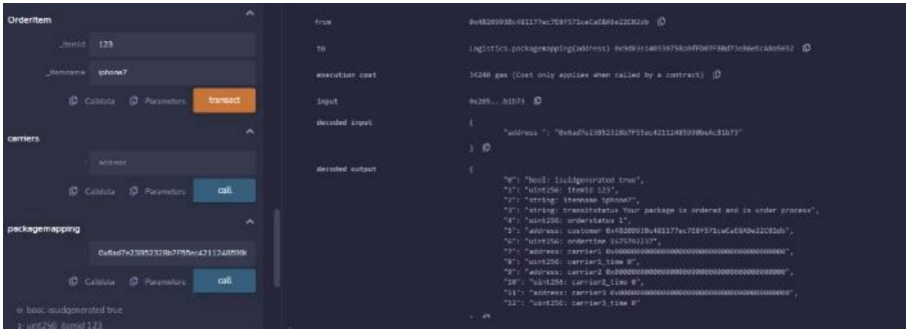


Fig. 9. Generating the Logistic Shipping Transaction

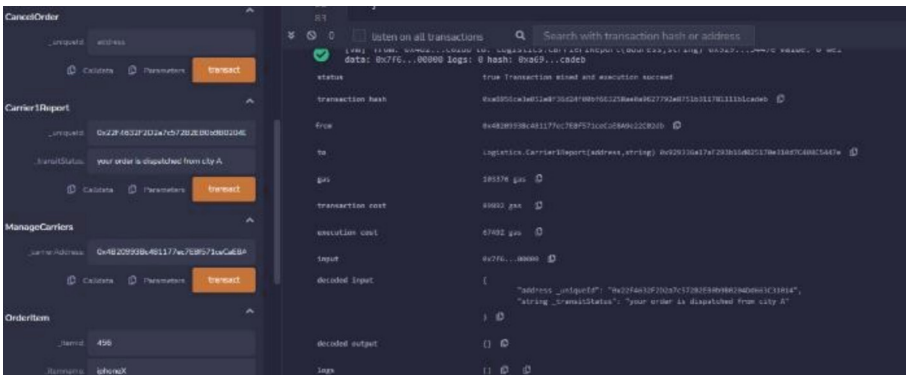


Fig. 10. Generating the carrier Reports for various stages

5 Conclusion

In conclusion, the logistics shipping sector has the potential to significantly improve the effectiveness and transparency of supply chain operations through the integration of blockchain technology and smart contracts. Logistics firms may improve procedures, boost transparency, and lower the risk of fraud or mistakes in the shipping process by utilising the secure, decentralised, and open characteristics of blockchain technology.

Many tedious procedures in the shipping sector, like tracking and confirming the delivery of products, issuing payments, and resolving disputes, can be automated using smart contracts. This can result in an improvement in speed and efficiency, as well as a decrease in the need for middlemen and a rise in mutual trust between all parties.

6 Future Scope

Blockchain technology and smart contracts are projected to be adopted by an increasing number of logistics organisations in the upcoming years because they provide a safe, effective, and affordable approach to enhance supply chain operations. Customers who

will profit from quicker and more dependable delivery of goods as well as logistics firms will also benefit from this.

Supply chain management, shipment tracking, and customs clearance are just a few of the logistics shipping applications for blockchain. Block chain technology can offer organisations real-time visibility into the location and status of goods, empowering them to take strategic actions. Block chain technology can also be used to track freight in real-time, giving clients the most recent details on their shipments [6].

Smart contracts can automate information flow, lower costs, and boost efficiency in logistics shipping. Smart contracts, for instance, can be used to automatically enforce a transportation contract's terms, doing away with the need for user involvement. Smart contracts can also be used to automate the payment process, which saves time and money compared to processing payments manually [7].

The logistics shipping sector could undergo a transformation thanks to blockchain technology and smart contracts, which would give companies more transparency, lower prices, and greater efficiency. These technologies will probably play a big part in the future of logistics shipping as they develop and become more commonly used, allowing companies to transport goods and services more effectively and efficiently [8].

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