Traceability in Fishery Supply Chain using Blockchain Technology:A Practical apporach

Madhuri N.Jadhav[a] , Shashikant Gupta[b]

Email ID: pdf.madhuri@lincoln.edu.my, shashigupta@lincoln.edu.my

[a]Postdoctrate researcher, Computer Science Engineering Department Lincoln University college,Malaysia, [b]Professor, Computer Science Engineering Department, Lincoln University college,Malaysia.

Abstract

There are many players in the food supply chain, it is challenging for consumers to protect their rights when they buy food such as a fish with quality issues. In addition to nutritional details, buyers are interested in the fish's place of origin, its storage and transportation practices, etc. In order to guarantee quality, safety, and regulatory compliance inside the food industry, traceability has grown in importance. Supply chain management of fisheries products requires effective traceability management. In order to effectively manage the traceability in fishery supply chain activities in a way that is decentralised, transparent, traceable, safe, unobtrusive, and reliable, we propose in this article an Ethereum blockchain-based traceability system in order to illustrate the efficacy and novelty of the proposed smart contract and solution architecture, a comparison of the former with the current blockchain-driven remedies will be made. Additionally, the architecture of the solution will be shown. The system greatly increased the producer's capacity to monitor and trace their products because it offered a transparent, safe, and effective way to use blockchain technology to comply and trace fishing products across the supply chain.

Keywords - Architecture, Blockchain, Capturing fisheries, Traceability system, Smart contract, Supply chain management.

1. Introduction

Food safety is a fundamental and important right for consumers. Despite various noteworthy advancements in food science and safety, foodborne diseases remain a significant global concern for general health. The Centres for Disease Control and Prevention (CDC) estimate every year, poisoned food kills approximately 48 million people worldwide. In the end, 3000 of them die and 128,000 end up in hospitals [35]. Throughout order to maintain food safety, quality, and regulatory compliance, traceability throughout the food supply chain is crucial. If a food product is contaminated, traceability can help identify the source of contamination and allow for targeted recalls or the

removal of the contaminated products from the supply chain. The authenticity and products quality can also be guaranteed with the aid of traceability. It is feasible to see any potential problems, such as improper handling, storage, or transportation, by tracing the flow of a product along the supply chain. When food goods are delivered to consumers, this can assist ensure that they are of the best quality. Basically, in the human diet fish and fish products are primary sources of protein. Gephart et al. claim that while fish consumption is rising annually, the seafood sector is likewise evolving. Half of the world's seafood is today produced by aquaculture, which has contributed most of the growth in fish consumption, as fisheries production, which is caught globally, has been nearly stagnant since the late 1980s [1]. Simultaneously, customers are growing more demanding and want to know not just the nutritional content of the fish they purchase, but also where it comes from and how well it is preserved throughout the supply chain. To do this, it is required to monitor every action across the whole fish value chain, from capture to plate. In other words, Throughout the entire value-chain of fish and fisheries, traceability must be used.

. However, fish may go through multiple businesses during the manufacturing or catch process before reaching the final consumer. This implies that multiple organisations may use the same fish or fish lot in their processes. Therefore, in order to fully understand the history of the fish, it is imperative that the internal procedures of each organisation participating in the value chain be integrated, the integration of these processes has been suggested in [2]. Additionally, Transparency about the supply chain can assist boost customer assurance, so it can promote consumer and business trust in the food industry. Allows the business to track the source of the issue and address it by tracking the dangerous food back through the food chain. Businesses can identify the origin and scope of safety or quality control issues with the use of traceability systems. Finally, traceability systems can increase supply chain effectiveness. Most of the time, consumers of fish products are unaware of the species they are consuming [9]. The expansion of effective product traceability systems has been made possible by the rising acceptance and popularity of digital technologies across a range of industry sectors. Quick Response (QR), Radio frequency identification (RFID), and Near Field Communication (NFC) codes are some of the most popular product tracking and tracing technologies. Nevertheless, even if these methods and tools are simple to use and straightforward to apply, they are not effective in handling fragmented data [10]. Therefore, these issues can be resolved by creating an effective traceability system [11]. Blockchain technology can solve the issues by uniting all parties involved in the supply chain on a single platform and offering a workable solution that ensures product traceability. A number of organisations have already effectively incorporated blockchain technology into their programmes, including Fishcoin, the Food and Agriculture Organisation (FAO), and the Worldwide Fund for Nature (WWF) [12], [13]. While combining blockchain technology with Internet of Things devices guarantees improved data

management and integrity, it is unable to effectively manage the supply chain's traceability for aquaculture [14], [15]. These days, blockchain is thought to be among the technologies that best satisfies supply chain traceability requirements. [3]. As demonstrated by [5],[6],[7], and [8], Applications of blockchain technology include distributed databases. [4],[5] in a variety of domains, including traceability in food supply chains and agriculture. Permissioned private blockchains (closed networks), permissioned public blockchains (hybrid blockchains), and permissionless public blockchains are the three categories into which blockchains can be divided [16], [17]. For seafood suppliers, it is currently impossible to thoroughly monitor the sources of the products while taking system maintainability into account. Many enterprises in the seafood sector use paper-based record-keeping techniques to maintain their records. The classic issues in our food supply chains today are fraud in the food industry, food poisoning, unlawful pro illicit manufacturing, and food repeal. Overall, traceability is essential for the food supply chain and can support customer trust, compliance, food safety, quality control, and supply chain effectiveness. Proposing framework using blockchain technology in this effort to accomplish product. Here, we make advantage of Ethereum, a public blockchain with no permissions.

The primary contribution of this study is as follows:

- We propose a Ethereum blockchain-based solution to handle the fishery supply chain operations in a decentralized, traceable, accountable, transparent, private, secure, and trustworthy manner.
- We present system architecture to explain the stakeholders and their interactions as well proposing smart contract to implement and test the functionalities of processes in the fishery supply chain.

The rest of the content of the document is organized as follows.: Related work is included in Section II. In Section III, stakeholders' interactions with the architecture are demonstrated and the suggested system is discussed with all stakeholders involved. We go over how smart contracts are utilised and executed in Section IV. Section V covers the security evaluation, comparative study, and generalisation aspect in addition to the result. In Section VI, we offer our last observations. A programmable blockchain technology like Ethereum can be utilised to handle the conceivable difficulties and enhance the current fish tracing techniques. The aim of our study is to create a reliable and secure blockchain-based fisheries supply chain tracing system.

2. Related work

In order to prevent potential food-related public health catastrophes, Authorities like the European Union implement regulations mandating item origin control and registration, enhancing product

traceability, and enabling expedited recalls when needed. As a result, numerous recommendations for implementing traceability have been made underneath food supply chains, particularly those involving fish products. The different blockchain and nonblockchain based platforms for tracing fish and fish products are then discussed.

2.1 Non blockchain based approaches

A system (named TraSiPesc) to track seafood and products from fisheries was proposed by the researchers in [18]. To design the system, the authors first identified the factors that affect end users' and Acceptance of traceability by customers in the fish and fisheries products industry. They also took into account the fundamentals of traceability, the legal structures of the national and EU governments, as well as the special features of the fishery industry. The authors of [19] suggest a monitoring tool's structural layout to enhance the supply chain traceability for Romanian fisheries. The device is meant to keep a lid on the quality and safety of fish and fisheries products. In Madagascar, Gardner et al. conducted research on the value chain, with a focus on octopus and mangrove mud crab [20]. In [21] and [22] Researchers underlined that the illegal use of food seasonings and glazing water on fish products is one of the rising problems with food fraud in the fishing supply chain.. Moreover, the study's conclusions demonstrate that one major obstacle is the absence of a widely accepted taxonomy for fish species. The authors of [23] put forth six crucial traceability guidelines for items derived from wild fish. Similar to this, the authors of [24] suggested six key concepts and four crucial instruments needed to create an effective traceability system. Complete chain tracking, tracking and exchange of digital information, accessibility and information availability to everyone, efficient monitoring post-transformation of products, verification, and identifying key information are all encapsulated in these six principles. But these studies just present theoretical ideas; they do not provide a workable prototype for an easily implementable traceability system across many organisations. The researchers of [10] examined the methods and strategies that seafood supply chain businesses now use. Furthermore, the study does not examine how to ensure transparency in the reliable exchange of data between all parties. The authors of [25] emphasised the requirements for tracking seafood products. Nevertheless, no system design or prototype for using these methods to stop seafood fraud and malpractice is shown in the study. The authors of [26] presented a manual, centralised design for monitoring the RFID-enabled supply chain's mobility for live fisheries. In the case that the central point fails, the data can be lost.

2.2. Blockchain based approaches

Strong characteristics of blockchain include provenance tracking, resilience to data loss, shared governance and operations, and auditability through the use of blockchain technology [27]. Thus, developing an effective traceability system is essential to determining the underlying features that

support to food fraud along the entire supply chain. In [34], the authors classified potential food scams in the supply chain of seafood. The majority of food fraud categories were IUU, species replacement, mislabelling, and replacement of fisheries. For reducing food fraud, the authors suggested few methods for control points. Traceability is implemented in the tilapia supply chain by Abderahman Rejeb in Ghana, from growers to the final consumers [28]. In Ghana, tilapia is one such to the annual number of cases of foodborne illnesses acquired domestically that are caused by 31 pathogens, US. Traceability of the most popular fish species. Using Ethereum and Hyperledger Sawtooth, Caro et al. provide a blockchain-based decision [29] to integrate traceability in agri-food supply chains. They evaluated and contrasted the latency, CPU, and network utilization of the two solutions. The creators of [3] are utilising blockchain technology to create a distributed application that gives customers access to data for tracking and calculating the carbon impact of goods and businesses. A blockchain-based traceability study of the fishing supply chain was delivered. [36]. The researchers in [30] investigated the blockchain application for managing the seafood supply chain to overcome the current issues in the seafood products' life cycle. The authors claim that combining NFC, RFID, and QR code approaches could aid in overcoming traceability issues. But these methods fall short of presenting a prototype [28]. [27] describes a study a study that enhanced Ghanaian fisheries supply chains through the usage of blockchain technology. Adding state-of-the-art technologies can improve traceability even more. However, the seafood supply chain is not new to blockchain technology or the Internet of Things. In a review paper published in [15], researchers emphasised the advantages of implementing IoT in conjunction with Blockchain technology. This study additionally explores the use of blockchain data storage by IoT devices to improve traceability management. The authors of [31] suggested a blockchain-based alternative as part of the implementation, which would lessen the scalability issues related to blockchain-based techniques for the fishing supply chain. Nevertheless, the risk and integrity elements of implementing blockchain in the fishing supply chain have not been covered by these approaches. The WWF carried out a pilot project on traceability in order to deal with the problem of illegal and immoral products entering the seafood supply chain. Ethereum smart contracts were used in this project to automate the supply chain processes [12]. Researchers of [32] recommends a blockchain-based fish tracing system for both farmed and wild fish that is built on Ethereum. However, this strategy lacks regulatory authority and does not offer a comprehensive justification for the actions of the accountable authorities.

3. Proposed Blockchain based solution

The model, which is an investment in the development of traceability systems, reflects the expansion of the current supply chain and includes data for each entity. Utilising blockchain technology offers security, transparency, and simplicity of access to the entities within it. The

conceptual blockchain supply chain model for goods derived from fisheries shows how each participant in the system interacts with the blockchain network. For many people worldwide, fishing has long been a source of food and a means of subsistence. We are suggesting using blockchain technology to promote transparency in the fishing sector as a solution to this technological issue. A possible remedy for the traceability of sustainable fisheries is blockchain technology. Traceability is essential to manage fisheries sustainably. Without it, it is more difficult for authorities to find and follow the origin of fish products, which could lead to unethical practices like illegal fishing and mislabeled products. Blockchain technology allows stakeholders to efficiently monitor and capture the fish products' journey from the point of capture to the time of sale. The traceability platform's smart contract needs to be registered and deliver traceability data. such that, given the context of the lot number's identity, the platform must give the history of the complete product addition to its current location or locations., including all activities and events that have taken place. Each operator is a participant (represented by an owner entity) in the blockchain since it is the owner's responsibility to collect and preserve details regarding the procedure that they are performing (such as processing, distributing, etc.) The conceptual blockchain supply chain model (Fig.1) for goods derived from fisheries shows how each participant in the system interacts with the blockchain network. To Identify necessary tracking and tracing for each stage of fishery supply chain it guarantees proper coordination amongst the various stakeholders and tracks every step a food lot takes from its point of origin to its destination—the consumer.

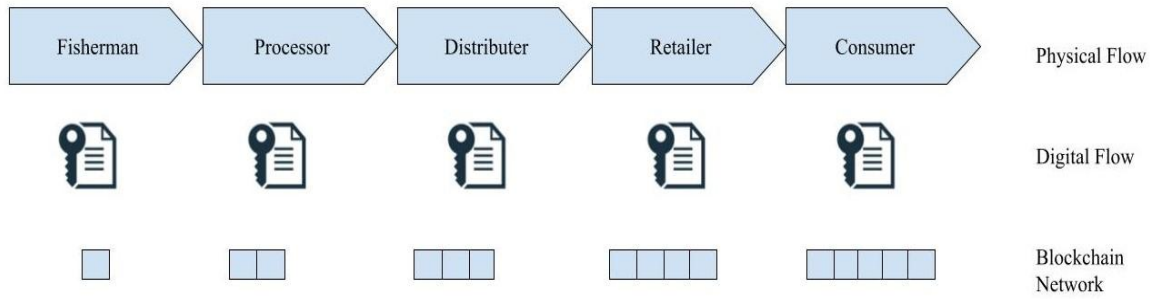

Fig.1. A blockchain-based information system processes the data from fishery products to consumer supply chain

The following roles are carried out by above mentioned entities in figure.,

Fisherman - This is where Processor will get fish lots to make further processing.

Processor - This person should adhere to a few rules.

Distributor - The fish lots are distributed to shops here.

Retailer - A typical consumer purchases from the retailer.

4. Smart contract implementation

The core smart contract of the traceability platform must be registered and must give traceability information. With reference to the designation of a fishlot number, the platform is required to

provide the current location of the lot (or places) and complete history. The declaration of the relevant input and a group of functions, including a constructor, make up a solidity smart contract. At a particular address on the Ethereum blockchain, this code can be found. The foundation of the entire application is the smart contract. It defines all the support functions and data structures that are required.

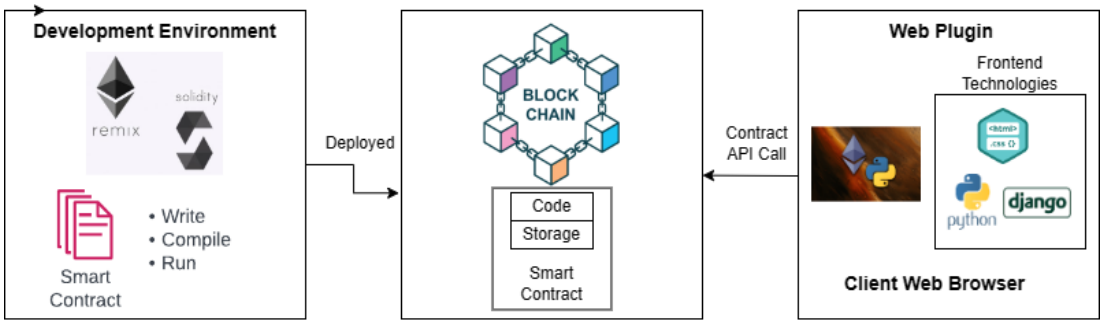

Fig.2. Architecture of traceability in fishery supply chain

Fig.2 shows the flow of proposed supply chain traceability, the smart contract is being written with Solidity which is then compiled, migrated, and deployed using Remix IDE on the Ganache blockchain network. The frontend uses Web3.py, Html-CSS, Django framework to communicate with the smart contract and blockchain network and remix Ethereum IDE is connect to Ganache Network to do Transaction between each component in Supply chain.

The proposed smart contract will function as follows:

The owner of the smart contract will be the one to deploy it; only he has the authority to authorize different roles, such as manufacturer, retailer, etc. Smart contract works with roles like fisherman- This is where Processor will get fishlot details for further processing, Processor This person should adhere to a number of regulations., Distributor- This individual delivers the fishlots to retailers. and Retailer- Typical clientele purchases from a supplier. With the help of this, we will monitor each and every fishlot that the owner orders. Smart contract will store information about the fishlot on the blockchain. As well contract will store all the information about fisherman, Processors, Distributors, and retailers on the blockchain and checks the availability for the same on the blockchain. For more trust and transparency smart contract include geotag image field which gives exact location and other image details of product lot. Owner will able to add any role in the contract as well able to add new fishlots in the blockchain. The implementation of several functions (addFisherman (), addProcessor (), addDistributor (), and addRetailer () enables the addition (storage) and reading of data from the blockchain. All things taken into account this smart contract offers a mechanism to monitor a fishery product's journey along the supply chain, guaranteeing accountability and transparency.

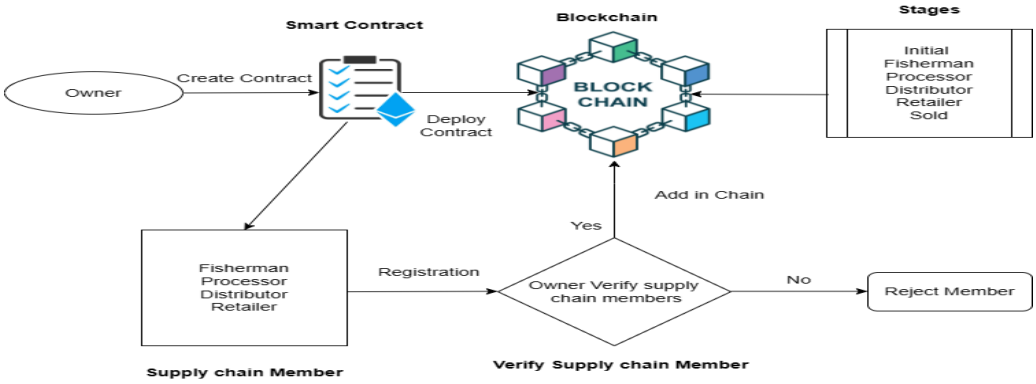

Fig.3. Workflow of smart contract for based on the blockchain supply chain traceability for fisheries.

All objects produced by the contract's operations and kept in the specified variables associated with storage are kept on the blockchain and are immutable. This implies that the framework in place is very resilient., utilizing the advantages of the blockchain (Segregation, consistency, security, and transparency). A contract that has previously been published cannot be changed, unless it is republished. Every entity depicted the domain model is put into practice by the contract as a "struct" with the necessary characteristics (https://github.com/MadhuriJadhav1234/BlockProject.git). To do this, each sort of event—such as processing, distribution, retailing, etc.—must have a FishlotID. The event mappings are made up of a mapping for each type of event that associates the FishlotID with the associated structure and a mapping for each event that allows the FishlotID to be used to determine the type of event. The function that enables the display of each event's stage is demonstrated. Every object created using the contract's functions and kept in the designated storage variables is kept on the blockchain and cannot be changed.

5. Result and Discussion

Result and discussion section focuses on result in the form Providing complete product traceability, from the time of lot packing to the point of delivery to the final customer with same lot number as well, we propose our solution's security analysis. Furthermore, we explore the generalization challenge and compare our solution with the existing solutions.

Result

Every participant which is a part of the supply chain for fishing could record and monitor all the information required for every stage in the supply chain on a decentralized, transparent, and safe platform made available by the application. The application was made to be accessible and easy to use. The application's data were immutable, which meant that once they were stored on the blockchain, they could not be changed or removed. This guaranteed the data's validity and integrity, which is essential for guaranteeing the food products' safety and quality. All things taken into

account, the implemented application's practical application shows ways to strengthen and safeguard food supply chain analytics with Blockchain technology. Thus, blockchain technology can improve the safety and quality of food items and increase consumer confidence in the food business by offering a decentralized, secure, and transparent platform. Researchers have previously used a time-consuming, ineffective, and error-prone method for traceability. As a result, there was a lack of transparency, which made it challenging to identify the precise cause of an issue in the event of a recall. Additionally, the producer ran the danger of the goods or its documentation being tampered with because they had to rely on the faith of intermediaries. On the other hand, the producer was able to follow the fishlot's path effectively and safely from production to consumption thanks to the Ethereum network application that was developed. Finally (Fig.4), Customer satisfaction has also increased as a result of the new traceability application. Customers' faith (Fig.5) in the product and the producer is heightened by the availability of comprehensive information about the fishlot's origin, stages, and quality at the time of purchase.

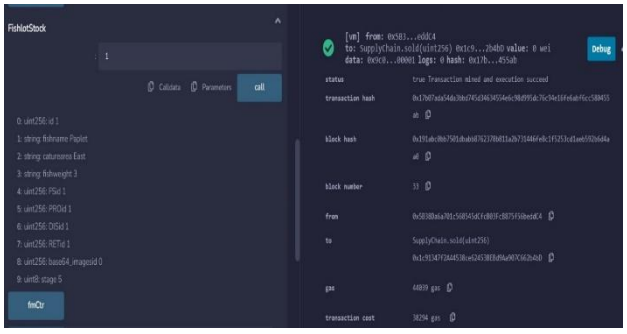

Fig.4. Result of the affected chain from the fishery trust.

Fig.5. Importing geotag image for consumer

traceability system .

Discussion

A. Security analysis: - Better security, robustness, and strength are provided by our solution. The key components and the specifics of our suggestion are delineated below.

• Data Integrity: Data integrity is seriously at risk from data exploitation.

The blockchain uses to safeguard data integrity using cryptography and immutability of transactions [35].

• Availability: The distributed nature of blockchain technology is what has made it so popular [35]. Every stakeholder in a decentralised system has access to the same data. Because of the Ethereum blockchain's is basis for the system, there is virtually no chance of denial-of-service assaults.

• Accountability: The activities of each participant are traceable and non-repudiable. using blockchain technology.. In this agreement Verifies the authenticity of all transactions that are started by the parties involved.

• Vulnerability study of smart contracts: Smart contracts with faults and vulnerabilities can have an impact on the blockchain system. In order to make sure the smart contract codes are secure, we have used the Oyente and SmartCheck tools to do a security study on them.

B. Comparison with the present approaches

We assess our suggested approach with the current blockchain-based and non-blockchain based alternatives in Tables 1 and 2. Table 2 shows that none of the solutions described offer a comprehensive traceability platform for supply chains involved in fishing. Likewise, none of the methods gives end-to-end transparency and is decentralized. Furthermore, these methods are centralized, making them susceptible to the problem with one particular point of failure. Nevertheless, the methods establish effective product tracking, with the exception of [24]. However, the suggested blockchain-based methods offer effective means of tracking and tracing.
Fishproducts.Apartfrom [33], every strategy uses a decentralised public blockchain platform to demo nstrate prototype solutions and effectively create product traceability across different fishing supply chains. But instead of concentrating on the supply networks for both farmed and wild fisheries. All the approaches aside from [32] primarily target the difficulties of a single kind of fisheries supply chain. Furthermore, none of the solutions include a security analysis of their smart contracts and blockchain driven system design they make use of.

Paper No. / Parameters	6	23	24	26	27	21	5	4	Our Solution
Prototype	√	×	√	×	√	×	√	×	√
Transparency	×	×	×	×	×	×	×	×	√
Decentralized	×	×	×	×	×	×	×	×	√
Traceability	√	×	√	√	√	√	×	×	√
Integrated	×	×	×	×	×	×	×	×	√

TABLE 1. A comparison of current non-blockchain alternatives.

Paper No. / Parameters	10	11	12	28	34	35	Our Solution
Prototype	√	×	√	√	√	√	√
Decentralized	√	√	√	√	√	√	√
Traceability	√	√	√	√	√	√	√
Integrated	×	×	×	×	√	×	√
Security analysis	×	×	×	×	√	√	√

TABLE 2. Comparison of our blockchain-based solutions with the ones that are presently in use.

Unlike the research mentioned above, our system is integrated; it combines a functional prototype solution with fishing supply networks. Additionally, the study suggests utilizing smart contracts and blockchain technology to improve the operations of the fishing supply chain. We performed the essential analysis to verify our solution's viability and its roles in the fishery supply chain, bringing the system into accordance with other sectors, and we constructed and tested our proposed framework using Remix IDE. Our technology makes it possible to apply the current product traceability management system for the fish sector on several blockchain platforms, improving its current characteristics. As a result, the fish sector can use our solution as a step towards improving its current practices.

C. Generalization

To fulfil the specifications of the fisheries supply chain for traceability, transparency, and security, we develop, test, and validate our recommended Ethereum platform system. Because blockchain systems are capable of efficiently encrypting data, our suggested method provides a safe and effective means to document (Fig.6) commercial transactions. Several sectors that handle product traceability, such the pharmaceutical, automotive, and logistics sectors, might also apply the suggested approach. The suggested fishery supply chain's components and operations can all be efficiently tracked and traced by the suggested method.

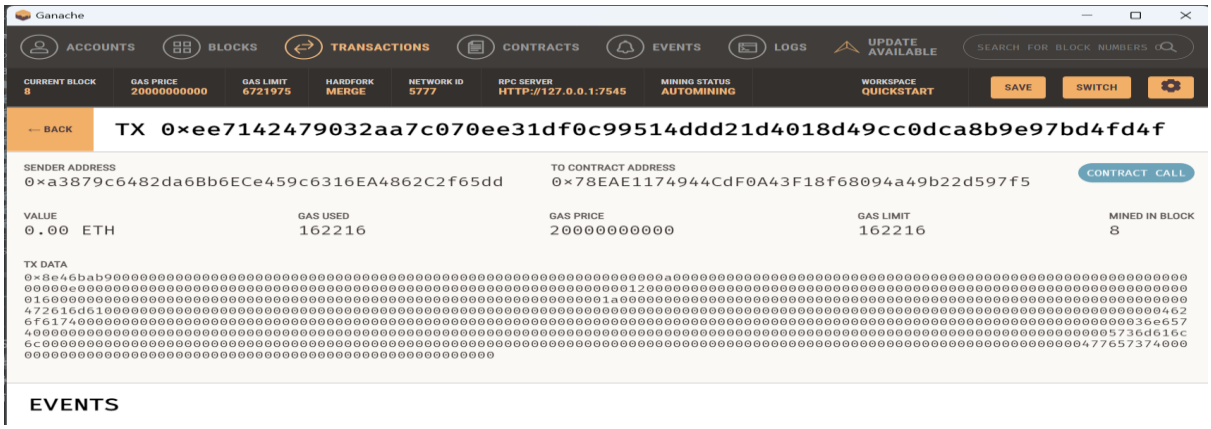

Fig.6. Blockchain platforms for recorded transactions, as they are effective at encrypting data.

6. Conclusion

The proposed blockchain-based approach to monitor and trace fish product lots in the fishing supply chain is transparent, accountable, secrete, protected, and dependable. Our suggested approach ensures open communication between parties, preventing various forms of fish fraud and malpractice. The smart contract has been developed to detect events and automate processes in the supply chain for fishing workflow of smart contract for traceability in fishery supply chain using blockchain along with their implementation steps, aspects of the testing and validation. Paper represents the security analysis must demonstrate that the solution is sufficiently protected in resistance to security risks and assaults. Comparing the suggested approach to current blockchain and non-blockchain-based alternatives demonstrates its uniqueness, efficacy, and generalizability to encompass a range of supply chain operations. We intend to create DApps for different stakeholders and implement and check out our solution on the real Ethereum network in the future. Proposed platform for supply chain management traceability in the fishing sector refers to the capacity to monitor and trace the flow of products and services at each step of the procedure. It includes tracking and documenting the movement of goods from the supplier to the client using cutting-edge technology.

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