Delivery Management System based on Blockchain, Smart Contracts and NFT: A Case Study in Vietnam

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Abstract— **Current traditional shipping models are increasingly revealing many shortcomings and affecting the interests of sellers and buyers due to having to depend on trusted third parties. For example, the Cash-on-Delivery (CoD) model must depend on the carrier/shipper, or the Letter-of-Credit (LoC) model depends on the place of the Letter certification (i.e., bank). There have been many examples demonstrating the riskiness of the two models above. Specifically, in developing countries (e.g., Vietnam), the demand for exporting goods and trading between sellers and buyers have not yet applied the benefits of current technology to improve traditional shipping models. Two typical examples in the last five years that have demonstrated the risks of both sellers and buyers when applying CoD and LoC models are the problem of keeping the money of the seller of GNN Expresses (2017) as well as risks in losing control of 4 containers of cashew nuts when exporting from Vietnam to Italy (2021). A series of studies have proposed solutions based on distributed storage, blockchain, and smart contracts to solve the above problems. However, the role of the shipper has not been considered in some approaches or is not suitable for deployment in a developed country (i.e., Vietnam). In this paper, we propose a combination model between the traditional CoD model and blockchain technology, smart contracts, and NFT to solve the above problems. Specifically, our contribution includes four aspects: a) proposing a shipping model based on blockchain technology and smart contracts; b) proposing a model for storing package information based on Ethereum's NFT technology (i.e. ERC721); c) implementing the proposed model by designing smart contracts that support the creation and transfer of NFTs between sellers and buyers; d) deploy smart contracts on four EVM-enabled platforms including BNB Smart chain, Fantom, Celo, and Polygon to find a suitable platform for the proposed model.**

Keywords—Letter-of-Credit; cash-on-delivery; blockchain; smart contract; NFT; Ethereum; Fantom; Polygon; Binance Smart Chain

I. Introduction

Today, delivery from sellers and buyers is growing constantly where many traditional shipping models (e.g. Cash-on-delivery (CoD)[1], Letter-of-Credit (LoC) [2]) to transportation models applying advanced technologies (e.g. blockchain, RFID, smart contracts) [3]. The main purpose of these models is to shorten delivery and pickup times and make it possible for sellers and buyers to trace the location and expected time of delivery [4]. For developing countries (i.e. Vietnam), the current delivery and receipt process still applies the traditional delivery and receipt model. Specifically, with the steps of delivery and receipt of goods within a city or between cities, the common model applied between sellers and buyers is CoD - the buyer will send money directly to the delivery party. The seller is responsible for shipping the item to the buyer through the shipping company (i.e. shippers). For cross-border transactions (i.e. between Vietnam and other countries - in the region or in the world), the commonly used model is LoC. All exchanges between the two parties are recorded and authenticated by a trusted third party (i.e. a bank).

However, both models have a lot of risks. With the LoC model, in case either party (i.e. exporter and importer) loses the original document (i.e. letter), the possibility of a loss of goods/money is very high. Because the seller only receives the full amount when the buyer receives the goods. For the CoD model, the seller must accept the risk of trusting and authorizing the shipping company (i.e. money, goods). Specifically, the number of goods that will be returned to the seller by the shipping company after a fixed period of time (e.g. monthly, quarterly) or a certain amount is reached. For this type of shipping, the risk for the seller is very high because the shipping companies can use their money for something other than sending the money back to the seller. Most of today's processing is based on an agreement between two parties (i.e. seller and carrier).

The application of traditional freight forwarding and payment models in Vietnam is facing a number of problems in the past five years. For the LoC model, in case one of the parties loses the original documents (i.e. letter), the possibility of losing goods/money is very high. A specific example happened in 2021 for the cashew nut export model from Vietnam to Italy. Specifically, four out of 100 containers of cashews exported from Vietnam to Italy are at risk of being lost because exporting companies in Vietnam cannot present original documents.[1] Fortunately this issue was resolved with the involvement of the State Department Vietnam and the Consulate General of Vietnam in Italy. For the traditional CoD model, an example of a seller being stolen by GNN Express occurred in Vietnam in 2017 and 2018.[2]. Specifically, the entire amount of goods worth about $154,900 was not transferred to the seller but was used by GNN Express for other purposes.

To solve the above problem, a series of models have proposed Blockchain technology and smart contracts to easily trace the origin of packages as well as reduce the risk from

[1]https://vietnamnet.vn /en/100-containers-of-cashew-nuts-exported-to-italy-suspected-of-being-scammed-821553.html
[2]https://vir.com.vn/gnn-scandal-rocks-delivery-segment-62710.html

untrusted parties. This model (i.e. in theory) can operate independently of a third party (i.e. no trusted third party required). However, if there is a conflict between the seller and the buyer, the arbitration must still be requested (i.e. the arbitrator receives a fee known as the conciliation fee). One of the popular examples of this pattern is Bitcoin[5], and Ethereum [6]. Specifically, all transactions will be routed through the seller/buyer's wallet address [7]. In addition, state-of-the-art has extended the above two models to solve the traditional freight problem (see the Related work section for more details). For research directions related to the transportation of goods for developing countries (i.e. Vietnam). There are not many in-depth approaches to ensure the transportation of traditional goods (i.e. see related work for more details).

In addition to the problems related to the implementation of a blockchain-based shipping system and smart contracts in Vietnam, the above method encounters some limitations when it ignores an important group of people who are shippers. Specifically, the role of this user group is ignored when shipping goods from the seller and the buyer. This can affect the arbitration process when there is any conflict between the seller, and buyer [8]. This has prompted several theoretical studies that combine the role of shippers using blockchain technology and smart contracts [9].

However, the above approaches still face a challenge when transporting packages between different shippers or shipping companies in Vietnam. In particular, packages can get damaged in transit - it's difficult to know who is responsible (i.e. seller, buyer, or carrier) as all interactions are done on paper and are not legally binding. Therefore, in this study, we aim to determine the package contents and related information when moving from seller to buyer. Specifically, we apply NFT technology to generate package-related information (i.e. sender, recipient, order content, weight, estimated delivery time, etc.). When the buyer receives the package, he can check the information sent from the seller. This technology is easy to deploy in developing countries because it does not require too high of a technology-based infrastructure to maintain the system. Some countries have implemented delivery models based on Blockchain, smart contracts, and NFT technologies.

Therefore, our contribution includes four aspects: a) proposing a shipping model based on blockchain technology and smart contracts applicable to the delivery environment in Vietnam; b) proposing a model for storing package information based on Ethereum's NFT technology (i.e. ERC721); c) implementing the proposed model by designing smart contracts that support the creation and transfer of NFTs between sellers and buyers; d) deploying smart contracts on four EVM-enabled platforms including BNB Smart chain, Fantom, Celo, and Polygon to find a suitable platform for the proposed model.[3]

The rest of the paper consists of seven parts. After the introduction is the related work section, which presents state-of-the-art with the same research problem. The next two sections present our approach and the proposed model implementation (i.e., Sections III, IV). To demonstrate our effectiveness, Section V presents our evaluation steps in different scenarios before making comments in Section VI. The Section VII summarizes and outlines the next steps for development.

[3]We do not implement smart contracts on ETH because the execution fee of smart contracts is too high.

II. Related Work

This section presents approaches from traditional shipping (i.e. post office, third party - courier companies, and e-commerce platforms) to proposed theoretical models based on technology. Blockchain and smart contracts.

A. Traditional Delivery Method

The demand for transporting goods is increasingly diverse (especially in developing countries). In this paper, we summarize the common approaches applied to Vietnam. In particular, the simplest approach is based on the postal system, which plays an important role in transporting goods. All information about the sender and receiver is done through a third party (i.e. bank employee)[4]. In the traditional model, shipping and delivery management is managed in a decentralized and centralized manner. Specifically, each city and province has a post office that acts as a receiving and transit point to sub-post offices in the districts (i.e. low-level). The post office in the district receives and sends the sender's item to a corresponding location on the package.

The benefits of this approach are low transportation costs and no need for smart devices/systems (i.e. smartphones, sensors). However, it also brings a lot of disadvantages i) it is difficult for users to get information about their packages; ii) long transit times; iii) if the recipient cannot be found, it will take time to send it back to the sender; iv) requires a large number of service workers due to lack of technology support (these risks are introduced in detail in the Introduction section).

In a more advanced approach, courier companies were born to ensure on-time delivery - with a higher fee. Specifically, courier companies will ensure delivery in the shortest time. A few popular courier companies in Vietnam include two groups: domestic courier companies: Viettel Post, Vietnam Post J&T Express[5] and has its headquarters abroad: Fedex[6], ASL[7], DHL[8].

In addition, e-commerce platforms have also changed the shipping trend in Vietnam in the past 10 years [10]. Specifically, e-commerce platforms act as intermediaries to link sellers and buyers. In other words, they bridge the gap between the two - finding products required by buyers and finding potential user groups for sellers. For sellers, they put their products on e-commerce platforms instead of having to open a store in real life. Buyers also save time shopping and commuting. Famous e-commerce platforms in Vietnam today include Lazada[9], Tiki[10], SenDo[11], Amazon[12], and Shopee [13]. In

[4]http://www.vnpost.vn/en-us/dich-vu/chi-tiet /id/183/key/parcel-post-service

[5]https://viettelpost.com.vn/activity- news/top-5-most-prestigious-and-quality-delivery-services-in-vietnam/

[6]https://www.fedex.com/en-vn/home. html

[7]https://www.asl-corp.com.vn/

[8]http://dhlexpress.vn/

[9]https://www.lazada.vn/

[10]https://tiki.vn/

[11]https ://www.sendo.vn/

[12]https://amazon.vn/

[13]https://shopee.vn/

addition, the role of freight is guaranteed by shipping companies of a small size (i.e. between cities or within the same city). These people will be the ones who directly receive the money from the buyer and deliver it back to the seller (i.e. Cash-on-delivery). The disadvantage of this model is that the seller can lose money when the delivery company goes bankrupt. The closest example to this is GNN Express[14]. Specifically, the company GNN Express took money from the seller to make up for the company's loss. Currently, this company is bankrupt and unable to pay. Another example related to cross-border freight took place in early 2021 between Vietnam and Italy. An Italian company exploited vulnerabilities in the Letter-of-Credit delivery method to hijack four containers of cashews. While the above issues have been addressed, we clearly see undeniable flaws in traditional delivery models.

B. Delivery Method based on Blockchain Technology

Previous approaches to deploying their proof-of-concept are mainly on the two platforms Hyperledger Fabric and Ethereum

1) Ethereum: The common point of these protocols is the use of ETH as the mainstream payment currency. For example, the Ethereum ecosystem has proposed `localEthereum` a method to facilitate transactions or DeFi Dapps between providers and claimants [7]. In addition, a new protocol that aims to help ship products from supplier to requester [11] has mined an ETH-based transaction to propose a COD/LOC mechanism. Similarly, `OpenBazaar` [12] is developed based on the extension of the Ethereum ecosystem, supporting sellers and buyers in the process of exchanging goods. Specifically, the transaction is identified based on the wallet address (i.e. transfers funds from the buyer's wallet address to the seller's wallet address) and is easily authenticated by the relevant parties without the need for a trusted third party. However, unlike `localEthereum`, `OpenBazaar` involves three parties: the provider, the requestor, and the moderator (that is, a new control role). Specifically, instead of just applying the entire transaction based on a default smart contract, `OpenBazaar` supports middleman (i.e. owner of smart contracts) to define corresponding policies and penalties to control the process. the process of transporting goods to determine the subject of compensation if an incident occurs. However, these systems suffer from a single point of failure problem - ignoring the role of the carrier. Specifically, the carrier will not be affected if there is any conflict between the seller and the buyer (i.e. purchase of poor quality goods, loss of the package) - even if it is the fault of the carrier's side [13].

2) Hyperledger Fabric: The common point between the approaches developed on the Hyperledger Fabric platform is to highlight the role of the carrier - the carrier is also responsible for the exchange of goods. Specifically, policies designed in the chain code (i.e. smart contracts) identify violations by all three groups of participants including seller, buyer, and person/shipping company[14]. For example, Son et al. [15] have proposed a baseline model of carriers, sellers, and buyers to replace the current CoD model. However, this approach requires no deposit constraints - conflicts are handled by a trusted third party (i.e. arbitration). To solve this problem, a few (e.g. [16], [17]) have proposed a model that combines blockchain technology and smart contracts in shipping packages between sellers and buyers. In which, the violations of the parties involved are sanctioned with a fee deducted from the previous deposit. Specifically, [17] supports a variety of shippers - multiple shippers can be involved in the delivery instead of just one object/shipping company as [16] suggests. To accommodate transit times (i.e. not limited by geographical distance), Duong et al. [18] proposes a new approach based on multi-section. For the purpose of supporting payment on a variety of platforms - users can create an account at one e-commerce platform and make purchases at all other exchanges. In addition to solutions to support sellers and buyers in the process of exchanging goods, Son et al. [1] also proposes a cross-platform model connecting many different markets, where sellers and buyers are not limited by payment tools between e-commerce platforms. Ha et al. [19] has proposed a personal information protection model (i.e. seller and buyer) based on the access control model [20], [21]. Specifically, sensitive information such as addresses and phone numbers can only be accessed by those with [22] permissions. This solution greatly helps in protecting the personal information of the seller and the buyer because this information is always available on other electronic exchanges (even those that do not play a role in the corresponding transaction). For cross-border transactions, Khoi et al. [2] have proposed a mechanism for transporting goods between countries that are not dependent on a trusted third party (i.e. bank) called Letter-of-Credit. This approach strives for an open policy across countries (i.e. unconstrained by the policies of one country, geographic region [23], [24]).

However, all of the above approaches are still bound when transferring orders between shippers or between seller - shipper or shipper - buyer. In particular, the package may be damaged in transit and it is difficult to determine who is responsible for this damage. To solve this problem, we propose a shipping model based on a combination of some outstanding technologies today, such as blockchain, smart contracts, and NFT. The next section describes in detail the model and how to operate the system.

III. Letter-of-Credit Chain Architecture

A. The Traditional Model of Freight Transport

In this section, we analyze the popular traditional freight model in Vietnam (i.e. CoD). Fig. 1 shows the six steps of shipping goods from the seller and the buyer. Specifically, the seller and the buyer discuss the price and form of payment. In Vietnam, this process is done based on social networking platforms (i.e. Facebook) or based on e-commerce platforms (i.e. sellers share product information and prices - buyers - buyers) product selection). The seller checks whether the product is in stock (step 2) before packing the product (step 3). In step 4, the seller chooses a reputable shipping company because the shipping company holds the customer's payment before returning it to them. Step 5 shows the process of shippers coming to pick up the goods from the seller and get the shipping address. Finally, the shippers ship the item to the buyer (step 6). The difficulties and risks of the traditional CoD model have been analyzed by us in the Introduction and Related work sections.

[14]https://vir.com.vn/gnn-scandal-rocks-delivery-segment-62710.html

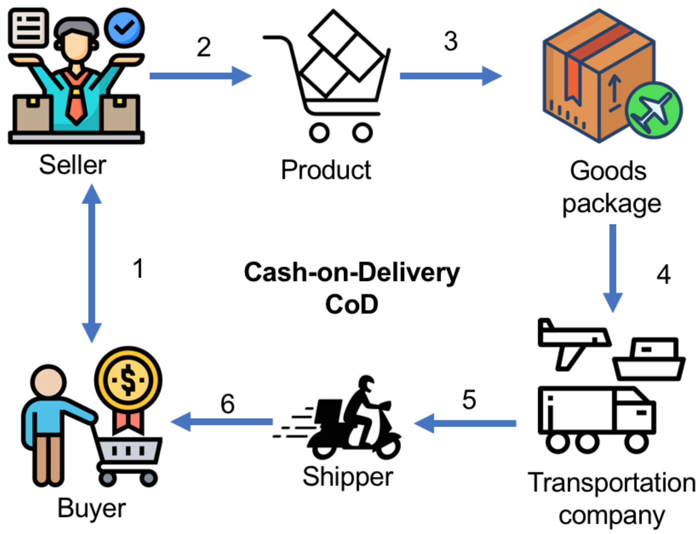


Fig. 1. The Traditional Model w.r.t cash-on-delivery of Freight Transport.

For the process of transporting goods between countries, we have an article that specifically analyzes the risks of the traditional model (i.e LoC) and presents the blockchain-based approach and smart contracts in the process. [2]. In this section we focus on solving the problem of transporting goods within the territory of Vietnam (i.e. between cities or within the same city). Depending on the shipping distance, step 6 (i.e. Fig. 1) includes one or more shippers. The next section presents our proposal process based on a combination of Blockchain technology, smart contracts, and NFT.

B. Cargo Transport Model based on Blockchain Technology, Smart Contracts and NFT

Fig. 2 presents our proposed model based on blockchain technology, smart contracts, and NFT (i.e. consisting of nine steps). We assume that the seller and the buyer have agreed on the delivery method as well as the price for the product. In this section, we design the system to move goods from seller to buyer. Specifically, step 1 shows the seller to pack the product and prepare the necessary declaration information related to the package (i.e. weight, unit price, item type, etc. see Implement section) in step 2 (i.e. based on system support services). These services call the respective functions in smart contracts to create a shipping contract (step 3). The seller selects the corresponding shipping company (step 4). Step 5 presents the deposit confirmation process for each participating group. In it, the seller still has to enter an amount of money to ensure delivery of the correct goods and of the right quality (i.e. if the seller intentionally violates the information provided in smart contracts - step 2 - this amount is used to compensation to the carrier and the buyer). For shippers, their management company must pay a guarantee fee to avoid the shipper losing the goods or in case the company goes bankrupt before the time to refund the buyer (i.e. the amount of money). Their deposit depends on the exchange between the seller and the shipping company). In the event of a conflict (i.e. shippers lose or damage goods or the shipping company goes bankrupt) smart contracts automatically transfer the company's deposit to the seller via their address. The buyer's deposit includes the shipping fee and part of the deposit of the product (i.e. depending on the agreement between the seller and the buyer). In case the buyer refuses to purchase the product, the shipping fee and deposit of the product are automatically transferred to the address of the shipping company and the seller, respectively. The above conventions are monitored through protocols designed on smart contracts and stored on NFTs with the consent of all three parties (i.e. seller, buyer, and shipping company) - step 6. Step 7 presents the shipping process between shippers (i.e. depending on the distance the number of shippers is 1 person or many). This process is managed and operated by shipping companies. Step 8 presents the final shipment (i.e. the buyer receives the item) - confirmation from the buyer that the package is correct and that the information is stored in the NFT. The transactions are conducted specifically, the buyer pays the remaining amount of the product; the shipping company receives the deposit and shipping; The seller receives the money for the sale of the product. Risks and breaches of contract are resolved based on the cases designed in step 5. Finally, smart contracts update transactions to the distributed ledger and prepare for a new shipping process.

IV. Implementation

Our reality model focuses on two main purposes i) data manipulation (i.e. package) - initialization, query and update - on blockchain platform and ii) generation of NFT for each order for easy traceability by sellers and buyers (i.e. product reviews before and after delivery).

A. Initialize Data / NFT

Fig. 3 shows the data row startup step packages. These package types include information related to the sender (i.e. receiving address, weight, type of item), and the recipient (i.e. receiving address, expected delivery time). In addition, the exchange and receipt of goods require an account deposit of all three parties depending on the purpose and transaction between the parties to ensure automatic conflict resolution on smart contracts. . In addition, information about which carrier belongs to which company, time, and place of delivery and collection is also added to the package's metadata. This is extremely important in cases where more than one shipper is involved in the transportation of household goods (i.e. the same or different shipping company). For storage, services support concurrent storage (i.e. processing partitions as a peer-to-peer network) on a distributed ledger - Supports more than one user for concurrent storage, the speed drop of the whole system. In general, the package data is organized as follows:[15]

```
goodsObject = {
"goodsID": goodsID,
"deliveryCompanyID": deliveryCompanyID,
"shipperID": shipperID,
"type": type of goods,
"buyerID": buyerID,
"sellerID": sellerID,
"quantity": quantity,
```

[15]The information related to the system participants is not listed in the article. Readers can read more about the group's previous research at [25], [18], [1].

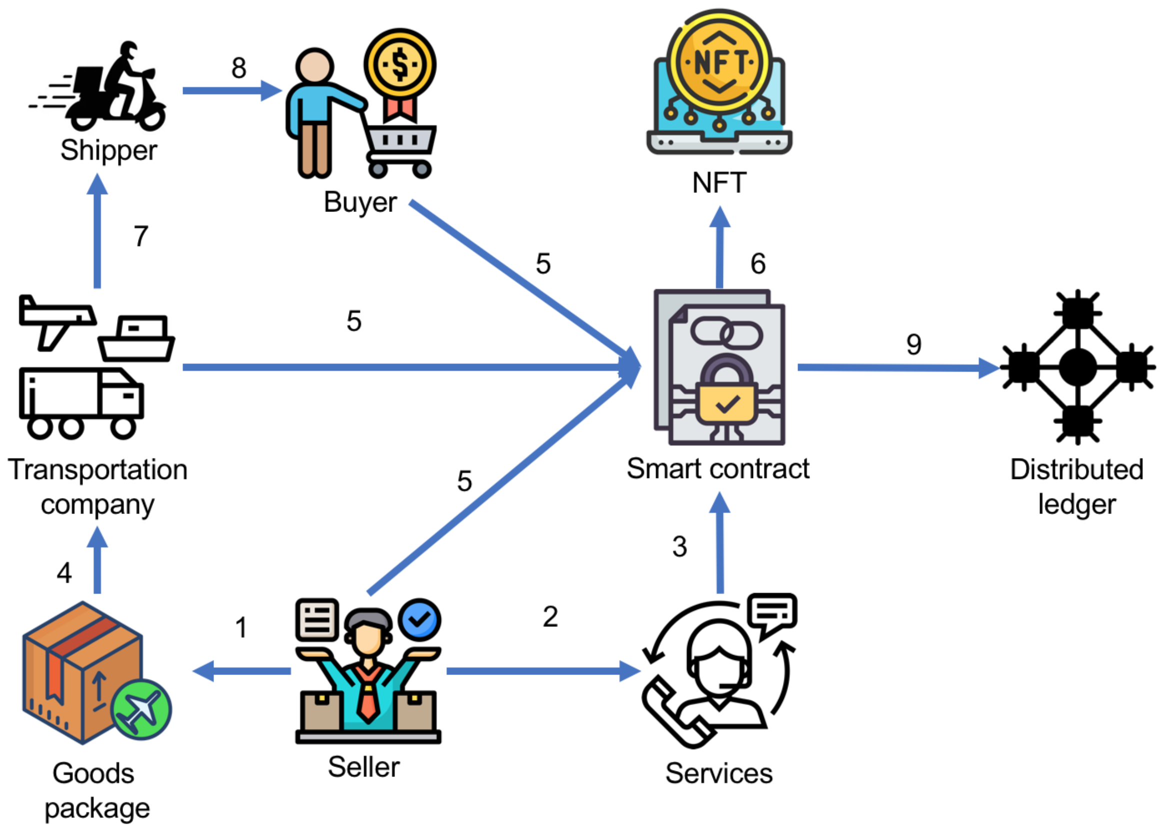


Fig. 2. Cargo Transport Model based on Blockchain Technology, Smart Contracts and NFT.

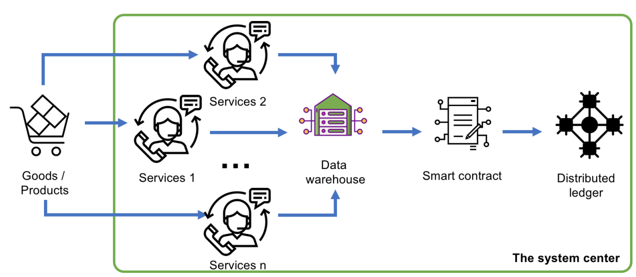


Fig. 3. Initialize Data/NFT.

```
"unit": unit,
"packageID": packageID,
"addressReceived": received address,
"addressDelivery": delivery address,
"time": estimated delivery time,
"location": location,
"state": Null
};
```

Specifically, in addition to information for content extraction (i.e. place of origin, weight, item type, etc.), we also store information regarding the status of the package at “addressReceived” (i.e. “state” - default value is Null). Specifically, “state” changes to 1 if the corresponding package has been received and shipped by the shipping company (i.e. “shipperID”); value 0 - pending (i.e. waiting for the shipper to pick up the item). In addition, “unit” stores the number of orders (e.g. 10) as well as which “packageID” they are assigned to. After receiving packages from the seller, the shipper checks them for compliance and waits for validation before syncing up the chain (i.e., temporarily stored on the data warehouse). Then the pre-designed constraints in Smart Contracts are called through the API (i.e. name of the function) to sync them up the chain. This inspection role is extremely important because they directly affect the shipping process of goods, as well as the premise for conflict resolution when any problems arise (e.g. damage. goods, lost packages). For the processes of initiating NFTs for orders (i.e. determining the deposit amount of the seller, buyer, and carrier), the content of the NFT is defined as follows:

```
NFT PACKAGE = {
"shipperID": shipperID,
"sellerID": sellerID,
"buyerID": buyerID,
"packageID": packageID,
"type": type of goods,
"quantity": quantity,
"addressReceived": received address,
"addressDelivery": delivery address,
"depositShipper": deposit of shipper,
"depositSeller": deposit of seller,
"depositBuyer": deposit of buyer,
"time": estimated delivery time
};
```

The information on the NFT contributes to conflict resolution (e.g. delivery delays). Definitions related to stakeholder deposit have been defined in our previous articles.

B. Data Query

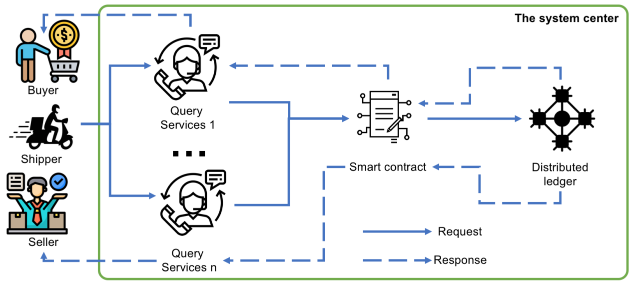


Fig. 4. Data Query.

Similar to the data initialization steps, the data query process also supports simultaneous access by many participants to the system (i.e. distributed model). Support services receive requests from shippers or sellers/buyers to access data (i.e. respective packages). Depending on the query object, we have different access purposes. Specifically, shippers query for the purpose of identifying consignee information and their addresses. In contrast, sellers/buyers view the status of their orders (i.e. after being delivered and received) as well as handling conflicts when something goes wrong. Fig. 4 shows the steps to query the order data. These requests are sent as requests (i.e. pre-designed services as API calls) from users to smart contracts available in the system (i.e. name of the function) before retrieving data. from the distributed ledger. All retrieval requests are also saved as query history for each individual or organization. For a shipping process that involves multiple discounts (i.e. multiple shippers delivering and receiving the goods before reaching the buyer's address), NFTs are similarly created between shippers (i.e. within or different shipping companies). In case the corresponding information is not found (e.g. wrong ID), the system will send a message not found results. For the NFT query process, all support services are provided as APIs.

C. Data Updated

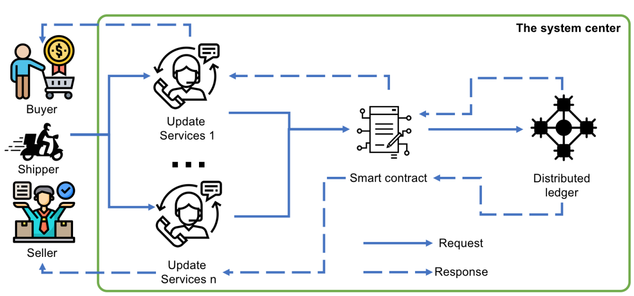
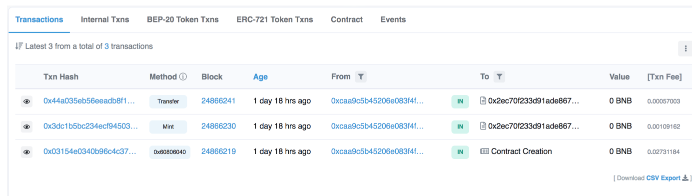


Fig. 5. Data Updated.

The data update procedure is invoked only after verifying that the data exists on the chain (i.e. after executing the corresponding data query procedure). In this section, we assume that the search data exists on the string. Where none exists, the system sends the same message to the user (see IV-B for details). Similar to the two processes of query and data initialization, we support update services in the form of APIs to receive requests from users before passing them to smart contracts (i.e., name of the function) for processing. The purpose of this process is to update the status of the package during transit as well as handle conflicts when something goes wrong (i.e. a combination of smart contracts and NFT). Fig. 5 shows the process of updating order data. For NFTs (i.e., available), the update process includes only the transfer from the owner's address to the new address (i.e., new owner). If any information is updated on an existing NFT, it will be stored as a new NFT (see IV-A for details).

V. Evaluation

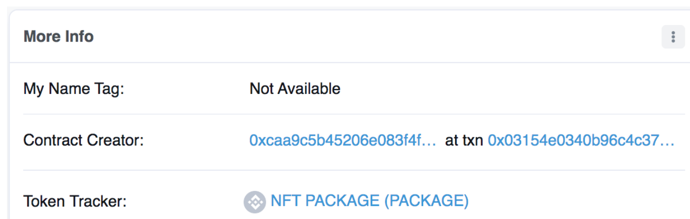

Transactions | Internal Txns | BEP-20 Token Txns | ERC-721 Token Txns | Contract | Events

Latest 3 from a total of 3 transactions

Txn Hash	Method	Block	Age	From		To	Value	[Txn Fee]
0x44a035eb56eeadb8f1...	Transfer	24866241	1 day 18 hrs ago	0xcaa9c5b45206e083f4f...	IN	0x2ec70f233d91ade867...	0 BNB	0.00057003
0x3dc1b5bc234ecf94503...	Mint	24866230	1 day 18 hrs ago	0xcaa9c5b45206e083f4f...	IN	0x2ec70f233d91ade867...	0 BNB	0.00109162
0x03154e0340b96c4c37...	0x60806040	24866219	1 day 18 hrs ago	0xcaa9c5b45206e083f4f...	IN	Contract Creation	0 BNB	0.02731184

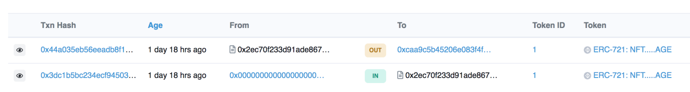
[Download CSV Export]

Fig. 6. The Transaction info (e.g., BNB Smart Chain).


More Info

My Name Tag:	Not Available
Contract Creator:	0xcaa9c5b45206e083f4f... at txn 0x03154e0340b96c4c37...
Token Tracker:	NFT PACKAGE (PACKAGE)

Fig. 7. NFT Creation.


Txn Hash	Age	From		To	Token ID	Token
0x44a035eb56eeadb8f1...	1 day 18 hrs ago	0x2ec70f233d91ade867...	OUT	0xcaa9c5b45206e083f4f...	1	ERC-721: NFT.....AGE
0x3dc1b5bc234ecf94503...	1 day 18 hrs ago	0x000000000000000000...	IN	0x2ec70f233d91ade867...	1	ERC-721: NFT.....AGE

[Download CSV Export]

Fig. 8. NFT Transfer.

Because of the connection model between seller - shipper - buyer and support for payment currency (i.e. consensus protocol), we implement the proposed model on blockchain platforms that support EVM instead of mining platforms. belongs to the Hyperledger eco-system. In addition, assessments based on system responsiveness (i.e. number of requests responded successfully/failed, system latency - min, max, average) were evaluated by us in the tests. previous research paper. Therefore, in this paper, we determine the suitable platform for our proposed model. Specifically, we install a recommendation system on four popular blockchain platforms today, supporting Ethereum Virtual Machine (EVM), including Binance Smart Chain (BNB Smart Chain)[16]; Polygon[17]; Fantom[18]; and Celo [19]. Our implementations on these four platforms are also shared

[16]https:// github.com/bnb-chain/whitepaper/blob/master/WHITEPAPER.md
[17]https://polygon.technology/lightpaper-polygon.pdf
[18]https://whitepaper.io/document/438/fantom-whitepaper
[19]https://celo.org/papers/whitepaper

TABLE I. TRANSACTION FEE

	Contracts Creation	Create NFT	Transfer NFT
BNB Smart Chain	0.02731184 BNB ($8.32)	0.00109162 BNB ($0.33)	0.00057003 BNB ($0.17)
Fantom	0.009576994 FTM ($0.001850)	0.000405167 FTM ($0.000078)	0.0002380105 FTM ($0.000046)
Polygon	0.006840710032835408 MATIC($0.01)	0.000289405001852192 MATIC($0.00)	0.000170007501088048 MATIC($0.00)
Celo	0.0070974384 CELO ($0.004)	0.0002840812 CELO ($0.000)	0.0001554878 CELO ($0.000)

TABLE II. GAS LIMIT

	Contracts Creation	Create NFT	Transfer NFT
BNB Smart Chain	2,731,184	109,162	3,000,000
Fantom	2,736,284	115,762	72,803
Polygon	2,736,284	115,762	72,803
Celo	3,548,719	142,040	85,673

TABLE III. GAS USED BY TRANSACTION

	Contracts Creation	Create NFT	Transfer NFT
BNB Smart Chain	2,731,184 (100%)	109,162 (100%)	57,003 (1.9%)
Fantom	2,736,284 (100%)	115,762 (100%)	68,003 (93.41%)
Polygon	2,736,284 (100%)	115,762 (100%)	68,003 (93.41%)
Celo	2,729,784 (76.92%)	109,262 (76.92%)	59,803 (69.8%)

as a contribution to the article to collect transaction fees corresponding to the four platforms' supporting coins[20], i.e. BNB[21]; MATIC[22]; FTM[23]; and CELO[24]. For example, Figure 6 details our three evaluations of a successful installation on BNB Smart Chain (i.e. similar settings are shown for the other three platforms). Our implementations to evaluate the execution cost of smart contracts (i.e. designed based on Solidity language) run on testnet environments of four platforms in order to choose the most cost-effective platform to deploy. reality. Our detailed assessments focus on the cost of performing contract creation, NFT generation (see Fig. 7) and NFT retrieval/transfer (i.e. NFT ownership update - see Fig. 8) presented in the respective subsections related to i) Transaction Fee; ii) Gas limit; iii) Gas Used by Transaction; and iv) Gas Price.

A. Transaction Fee

Table I shows the cost of creating contracts for the four platforms. It is easy to see that the highest transaction fee of the three requirements is contract creation for all four platforms. In which, the cost of BNB Smart Chain is the highest with the highest cost when creating a contract is 0.02731184 BNB ($8.32); whereas, the lowest cost recorded by the Fantom platform with the highest cost for contract initiation is less than 0.009576994 FTM ($0.001850). Meanwhile, the cost to enforce Celo's contract initiation requirement is lower than Polygon's with only $0.004 compared to $0.01. For the remaining two requirements (Create NFT and Transfer NFT), we note that the cost of implementing them for all three platforms, Polygon, Celo, and Fantom is very low (i.e. negligible) given the cost. trades close to $0.00. However, this cost is still very high when deployed on BNB Smart Chain with 0.00109162 BNB ($0.33) and 0.00057003 BNB ($0.17) for Create NFT and Transfer NFT, respectively.

B. Gas Limit

Table II shows the gas limit for each transaction. Our observations show that the gas limits of the three platforms (i.e. BNB, Polygon, and Fantom) are roughly equivalent - where Polygon and Fantom are similar in the first two transactions. Particularly in the third transaction, BNB's gas limit was extremely high at 3,000,000. While the gas volume of Polygon and Fantom is equivalent to 72,803. The other platform (i.e., Celo) has the highest gas limit in the first two transactions with 3,548,719; 142,040, respectively.

C. Gas Used by Transaction

Table III shows the amount of gas used when executing the transaction (i.e. what percentage of gas in total gas is shown in Table II). Specifically, the three platforms BNB, Polygon, and Fantom use 100% of the Gas Limit for the two Contracts Creation and Create NFT transactions. Meanwhile, Celo uses 76.92% of the Gas limit for the above two transactions. For the last transaction of Transfer NFT, BNB's Gas level was only 1.9% with 57,003 (i.e., lowest) while the highest Gas level was recorded by Fantom and Polygon with 93.41% of Gas limit; while BNB and Celo use 79.17% and 69.8% of Gas limit.

D. Gas Price

Table IV shows the value of Gas for all four platforms. Specifically, BNB, Fantom, and Celo have the same Gas value in all three transactions with values of 10 Gwei (i.e. the highest of the three platforms), 3.5 Gwei, and 2.7 Gwei, respectively. Meanwhile, the Gas value of Polygon platform (i.e. MATIC) has the lowest value and fluctuates around 2.5 Gwei.

VI. DISCUSSION

According to our observation, the transaction value depends on the market capitalization of the respective coin. The total market capitalization of the 4 platforms used in our review (i.e. BNB (Binance Smart Chain); MATIC (Polygon); FTM (Fantom); and CELO (Celo)) are $50,959,673,206, respectively; $7,652,386,190; $486,510,485; and $244,775,762.[25] This directly affects the coin value of that platform – although the number of coins issued at the time of system implementation also plays a

[20]Implementation of theme models our release at Nov-24-2022 07:42:20 AM +UTC

[21]https://testnet.bscscan.com/address/0x2ec70f233d91ade867259ff20c75f5c54e1ff008

[22]https://mumbai.polygonscan.com/address/0xd9ee80d850ef3c4978dd0b099a45a559fd7c5ef4

[23]https://testnet.ftmscan.com/address/0xd9ee80d850ef3c4978dd0b099a45a559fd7c5ef4

[24]https://explorer.celo.org/alfajores/address/0xD9Ee80D850eF3C4978Dd0B099A45a559fD7c5EF4/transactions

[25]Our observation time is 12:00PM - 11/26/2022.

TABLE IV. GAS PRICE

	Contracts Creation	Create NFT	Transfer NFT
BNB Smart Chain	0.00000001 BNB (10 Gwei)	0.00000001 BNB (10 Gwei)	0.00000001 BNB (10 Gwei)
Fantom	0.0000000035 FTM (3.5 Gwei)	0.0000000035 FTM (3.5 Gwei)	0.0000000035 FTM (3.5 Gwei)
Polygon	0.000000002500000012 MATIC (2.500000012 Gwei)	0.000000002500000016 MATIC (2.500000016 Gwei)	0.000000002500000016 MATIC (2.500000016 Gwei)
Celo	0.0000000026 CELO (Max Fee per Gas: 2.7 Gwei)	0.0000000026 CELO (Max Fee per Gas: 2.7 Gwei)	0.0000000026 CELO (Max Fee per Gas: 2.7 Gwei)

huge role. The total issuance of the four coins BNB, MATIC, FTM, and CELO is 163,276,974/163,276,974 coins, respectively; 8,868,740,690/10,000,000,000 coins; 2,541,152,731/3,175,000,000 coins and 473,376,178/1,000,000,000 coins. The value of the coin is conventionally based on the number of coins issued and the total market capitalization with a value of $314.98; $0.863099; $0.1909; and $0.528049 for BNB, MATIC, FTM, and CELO, respectively.

Based on the measurements and analysis in Section V, we have concluded that the proposed model deployed on Faltom brings many benefits related to system operating costs. In particular, generating and receiving NFTs has an almost zero fee (i.e. negligible). Also, the cost of creating contracts with transaction execution value is also very low (i.e. less than $0.002).

In future work, we proceed to implement more complex methods/algorithms (ie, encryption and decryption) as well as more complex data structures to observe the costs for the respective transactions. Deploying the proposed model in a real environment is also a possible approach (i.e. implementing the recommendation system on the FTM mainnet). In our current analysis, we have not considered issues related to the privacy policy of users (i.e. access control [25], [20], dynamic policy [23], [24]) - a possible approach would be implemented in upcoming research activities. Finally, infrastructure-based approaches (i.e. gRPC [26], [27]; Microservices [28], [29]; Dynamic transmission messages [30] and Brokerless [31]) can be integrated into the model of us to increase user interaction (i.e. API-call-based approach).

VII. CONCLUSION

Our research paper aims to expand the traditional delivery system (i.e. dependent on trusted third parties). For example, in the CoD model, the shipper receives the product deposit and payment from the buyer and then passes it back to the seller. The article highlights the risks in applying traditional models as well as the limitations of current approaches. Thereby, we propose a model that combines Blockchain technology, smart contracts, and NFT to eliminate the role of a trusted third party. Specifically, in our proposed model, the deposits of all three parties (i.e. seller, buyer, and carrier) are stored and noted as NFTs - the processing is stored in smart contracts. We have implemented the proposed model as proof-of-concept based on the Ethereum platform and Solidity language. We also deploy our smart contracts on four popular platforms supporting EVM (i.e. BNB, MATIC, FTM, CELO). Our analysis on all four platforms in all three transactions (i.e. contracts creation, NFT creation, NFT transfer) found that our proposed model is suitable for installation on the Fantom platform - having the lowest transaction costs compared to the other three platforms. Possible development directions for our proposed model are presented in the discussion.

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