



Privacy Preservation Agri-Food SCM Operation Based on Online/Offline RFID Using Block Chain

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Abstract. The state-of-the-art Supply Chain (SC) becomes more complex and effective not only for the business viewpoint but also for environmental care and sustainability. Despite the current progress in realizing how RFID systems can considerably advance agri-food maintenance, there is a major gap in the storyline relating to factors of RFID application in managing several forms of agri-food supply chain operations. Therefore, this study struggles to meet this gap by studying the key enablers and obstacles of using RFID techniques in agri-food supply chain operations using the IoT devices, group behavior, and ecosystem framework. Second, the effects of offline and online RFID deployment in measuring agriculture supply chain barriers. The goal of this work is to propose a systematic strategy block chain is a public unchangeable database that can be able to secure the data from any interference or any kind of revision. However, the record of the data is not making sure that the place of origin or record of ownership of any products. There is a need to model wherein every product which belongs to the different producers have their own private key for each product and has one smart contract. Our proposed solution using a Blockchain smart contract that allows the supply chain to traceability the products all over their whole life cycle as well as preserve the privacy.

Keywords: RFID · Privacy Preservation · Supply chain

1 Introduction

Agriculture contributed significantly to the emergence of our agrarian human existence. As a result, among numerous sectors, agriculture has received the highest priority for achieving sustainable growth, with an emphasis on implementing strategies in agriculture [1]. Producer, consumer, agricultural vendors, processor and distributor, non-government organizations (NGOs), domestic and global agricultural bodies, government, linked associated institutions, and others are all part of the agriculture food supply chain (AFSC). In AFSC, each phase contributes a distinct value to the goods [2]. Fresh foods AFSC and processed AFSC are two types of AFSC. Primary grain growing, wholesale, import-export, and retailing, as well as raw products and other services suppliers, make up the fresh foods AFSC. Processed AFSC, on the other hand, produces agri-products acquired from the processing of raw food grains, which results in higher quality. The value of the raw food is boosted by growing circumstances [3].

Traditional AFSCs are having difficulties obtaining, storing, and disseminating agri-food deficits and deteriorations [4]. Due to the complexity of modern technology, communication, transportation infrastructure, and commercial transactions among countries, intermediaries, and dealers, AFSC has become increasingly difficult in recent years [5]. The requirement for AFSC is mostly due to a lack of coordination, which leads to inadequate traceability of AFSC communications, higher logistics time, and increased monitoring expenses for agricultural products in order to maintain their quality and safety. These problems that corporations confront when it comes to interacting suppliers and customers, particularly in the agri supply chain, where partners are interdependent [6]. Concern about food safety and hygiene, as well as the uncontrolled depletion of resources, have been raised by the AFSC environment. To grasp the intricacies and comprehensive features of any value chain, a systems view is required [7]. To address these issues, the AFSC requires an adoption of new technology for food safety, security, and sustainability.

21st century is a breakthrough that gives the industry a whole new viewpoint on how to interact with new technology to produce the most output with the least amount of resources [8]. In the AFSC, an adoption of new technology improves industrial processes, increasing productivity, and reflecting individual needs and short-term management goals [9]. These technologies have gained traction due to their ability to increase food quality and safety, shelf life, climate change adaptation, food loss, waste reduction, and sustainable resource usage [10].

We have seen developing technologies have a substantial impact on supply chain sustainability in the recent past. In AFSC, technologies such as RFID is utilized to automate operation, irrigation facilities, forecasting, traceability, equipment, water management, remote sensing, and environmental monitoring [11]. RFID is a form of auto identification that uses two sorts of equipment: a reader (controller of the connection), and tags, which have a corresponding electronic code. The tags reply with their unique identifier when the reader uses radio frequency (RF) impulses to query them (ID) [12]. RFID also improves AFSC by improving interconnection in logistics, cold chain, human effort, and resource management [11].

Prior research has attempted to determine that food traceability is the ability to follow a product across the whole supply chain at any step, beginning with manufacturing,

processing, or distribution, until it reaches consumers [11, 13], highlighted that RFID benefits include in data transparency, traceability, and security, once put forward, it produced widespread interest in many fields, such as evaluating businesses online with RFID implementation will be instructive and beneficial in each stage of the supply chain. [2] However, [14] pointed out that RFID is one of the key technologies for detecting smart objects such as vehicles in smart cities, which has become critical for addressing traffic issues. Also, unlike barcodes, RFID tags can be read from several meters away and don't have to be in the direct path of the reader. So, in the near future, the traditional barcode system will be phased out in favor of the RFID authentication system, which makes it easy to scan large amounts of data quickly [15].

According to a number of authors, RFID has inspired substantial interest in recent years, particularly in industries that require rigorous monitoring of goods, and it allows concerned parties to gather information about objects at every level of the SC [16]. In comparison to any other value chain, fresh food handling is more involved and costly. This is due to the items' low shelf lives, susceptibility to temperature and humidity, and the possibility of contamination during harvest, transportation, processing, packaging, or handling, as well as shipment. In other words, the greater the time span between the various steps of the value chain, the more likely the food quality will decline [17]. However, RFID technology is worth investing in because of the multiple benefits it provides, including effective tracking, reduced food waste, assurance of safe and high-quality food products, improved stock management, and lower labor costs [18]. RFID systems are currently beginning to capture new marketplace, contrast to barcodes.

A series of recent studies has indicated that, food safety is a top concern for consumers. Food industry engagement in global supply chains is critical for improving income and market orientation, as well as upgrading quality control, product integrity, safeguards, and associated transparency [19]. Food businesses have expressed interest in RFID because ensuring food security, quality, traceability, and complex challenges in the AFSC [20]. Emphasized that increased food wastage due to the complexity which exists in synchronizing the members of the food supply chain. There is a growing awareness in society that wasting perishable meals wastes creates significant amount of natural risk [21]. Nowadays, Buyers became more demanding and aware of product source and quality, and hence desire real-time awareness of their products throughout the supply chain. As a result, RFID use is becoming increasingly important in logistics systems for tracking commodities as they move through the value chain [22].

A large number of existing studies in the broader literature have examined RFID deployment in the AFSC can improve the monitoring system of numerous variables such as crop productivity, fertilizer use, water efficiency, and so on [23]. RFID is widely used in the food industry to track temperature during storage and transit, as well as to estimate shelf life [24]. Other RFID uses include SC management [23], monitoring, inventory management, cold chain monitoring, and food product traceability [25]. Furthermore, the use of RFID in the agri-food business has been shown to improve process efficiency and transparency, strengthen trustworthiness, and eliminate superfluous middlemen from the supply chain, as well as increasing customers' confidence in traceable food products [26].

According to [27] RFID tags is already widely used in the retail industry. It can assign a unique identifier to each product in a store; it can minimize the need for personnel and eliminate human mistake by automating operations; and it can scan many products at the same time. When compared to barcodes, RFID surpasses due to its ability to send precise, high-capacity data at a faster rate. Nonetheless, the most significant disadvantage of this technology is its high implementation cost [28]. Furthermore, RFID is being used not only to improve product safety and quality, but also to promote consumer happiness and loyalty, giving them a competitive advantage over their competitors. As different benefits can contribute to distinct competitive gains, this study mapped and presented the comparative benefit of implementing RFID in a supply chain in order to correlate benefit-drivers with different competitive advantages [29]. Managers' capacity to make confident judgments, on the other hand, increased trust that the data is dependable and secure. Using RFID technology, they may also be able to trace and inspect items purchased in the SC system. The cost of recalling could be reduced by being able to determine where faulty materials enter the supply chain [30].

The existing research showed mechanisms of Online/Offline RFID technology design in the AFSC. Despite this, it has paid little attention to supply chain actors' inclinations for Online/Offline RFID technology adoption, barriers and benefits. As a result, we plan to fill a potential research void in the literature by looking into the determinants or variables of technology adoption and offering adaptable, transparent, trackable, and interoperable solutions for AFSC [31]. Wasted food and supply chain losses, as well as poor infrastructure, capacity planning, the challenge of fresh produce tracking, the collection of a high volume of trustworthy data, information distortion, and data exchange, are all major issues that must be addressed [32]. In light of this, the goal of our research is to see how much support there is in the peer-reviewed literature for a more comprehensive approach to operation based on Online/Offline RFID in AFSC and evaluating their combined impact. The study focused on online/offline RFID operation, associated barriers and benefits in AFSC. However, our findings suggest that RFID implementers in the agro supply chain consider fewer barriers and higher benefits. We proposed a systematic strategy using analytical models for determining the degree of Offline and Online RFID adaptability and reducing the impact of barriers in the agri-food supply chain. The study's goal is to determine adaptive determinant factors, barriers, and benefits of the Online/Offline RFID in AFSC.

As a result, this research makes the following contributions: (1) Identifying Online/Offline RFID adaptive determinant factors; (2) associated barriers impact on AFSC operation; and (3) RFID adoption benefits in AFSC. This study offers recommendations for practitioners who want to improve their AFSC performance. The remainder of the research is structured as follows. Through a literature study to SSSC, Sect. 2 tackles the adaptive determinant factors, barriers, and benefits and proposed approach. In Sect. 3 shown our proposed method, block chain and smart contract algorithm, RFID, and its security. Section 4. Finally, the study's shortcomings are discussed, as well as suggestions for further research.

2 Related Work

In this section, we conduct a review of the literature on operation Based on Online/Offline RFID and associated barriers and benefits in the AFSC. We aim to identify the potential research gap from this review and for richness and simplicity; we divide the review of literature into three sub-sections. The first one is related to Online/Offline RFID adaptive determinants in AFSC and, their relative importance, relationship, or utility in the supply chain management. The second part pertains to discuss barriers affecting the performance of the AFSC. The third section deals with benefits of implementing Online/Offline RFID in AFSC.

2.1 Online/Offline RFID Adaptive Determinants in AFSC

With great work put into its proper adoption, RFID is becoming highly prevalent on the market due to gains in efficiency, security, and reactivity. It will be necessary to have economical RFID tags with great performance for the innovation to be utilized on the market. The use of RFID for supply chain traceability suggests that the adoption of Online/Offline RFID sensor tags in a variety of industries, including the AFSC, is only a matter of time. The global RFID market should grow as a result of the democratization of RFID technology, which includes lower tag costs and the establishment of infrastructures capable of handling large volumes of RFID tags [33]. In the food industry, RFID has seen widespread use. This is because, as a result of globalization, AFSC has gotten more complex, and RFID provides end-to-end traceability of food items acquired from many nations. It becomes incredibly difficult to quickly detect the source of food product contamination and handle other quality concerns such as freshness without RFID-enabled tracking. Implementation costs were significant when RFID was first introduced, but as the technology has grown, they have decreased. Outsourcing has become one of the most important competitive strategies as a result of globalization.

The degree of difficulty and threat grows as a supply chain expands into a global market. RFID can help solve this problem by allowing for real-time sharing data and integration [34]. It is critical to implement a reliable source of traceability data. As a result, we examine the situation in which the AFSC industry employs RFID-tags as a platform for traceability information rather than Bar-codes by examining the liability costs (produced if contamination happens) based on the traceability information obtained from these tags [35]. There is also existing research on location privacy systems in which the location server (LS) is also unreliable. It is self-evident that using an Online/Offline RFID system can ensure a higher level of anonymity, as distinct dynamical pseudonyms could be used for each geolocation query, preventing the LS from knowing the tag's true identity [36].

2.2 Affecting Barriers in AFSC Performance

The high cost of RFID technology is a major impediment to its widespread adoption. It should be reduced as low as feasible in order to avoid affecting the total value of meals. A high price would be inappropriate since it would cause consumers' buying habits to change [37]. While RFID has proven to be useful to businesses, supply chain managers must weigh the costs of deployment against the benefits of adopting new technologies [38]. As to have less transportation costs, a producer may opt to sell his gathered produce to the nearest warehouse. However, taking into account environmental factors such as temperature and humidity, which may result in a greater contamination rate at farmer warehouses or traditional storage, resulting in more contaminated agro food being wasted. As a result of the items' short shelf life and susceptibility to temperature and humidity, fresh food management is more challenging. This necessitates the use of properly cooled storage, as well as improved environment storage and transportation facilities. RFID enables real-time item tracking and tracing, reducing the proliferation of fake products and reducing product fraud in retail businesses. If companies want to satisfy customers, they need to be sensitive enough to detect and analyze their products [39].

A total lack of understanding Less technical knowledge and skills about RFID and its application are frequently mentioned, followed by "employee opposition. One of the primary obstacles impacting technology uptake in AFSC is a lack of training facilities for personnel with non-specialized background. The bullwhip effect, or the phenomena of modest swings in need at the retail level producing enlarged volatility at the retail, wholesaler, manufacturer, and raw material supplier's levels [10], may be caused by a lack of information exchange in the supply chain. Higher distribution and expenses of agricultural goods for preserving their safety and reliability due to increased time lag of agro—based product delivery, owing to a poor coordinating structure of AFSC bodies and information. During the logistics process, an RFID-integrated technique speeds up resource deployment, eliminates waste, and increases the durability, sustainability, and traceability. As a result, logistical durations can be shortened, and efficiency enhanced [11].

2.3 Benefits of Implementing Online/Offline RFID

The labor cost reduction potential is one of the primary cost-saving potencies of RFID that has been highlighted in several studies. This is largely since RFID tags may be scanned automatically without the need for human interaction, lowering the expenses of shipping, selecting, storage, tracking, and physical inventory counts [4, 10]. RFID tags may be read through practically any non-metallic material, as well as in extremely hot conditions. This endurance is a crucial advantage for enterprises using RFID over barcodes, which disintegrate in bad weather conditions. Traceability allows businesses to track sales and arrange discounts, as well as trace raw material and recalls across the supply chain, all of which improves their competitiveness [6]. RFID is widely used in the food industry to track temperature during storage and transit, as well as to estimate shelf life. The use of RFID technology to monitor manufacturing and processes in real time might be regarded a genuine and useful tool. Barcodes are less efficient than RFIDs.

RFID is faster, more precise, and have a larger storage capacity than bar codes, making them ideal for maintaining the freshness of farm produce [40].

RFID allows data to be collected in a way that is transparent to all parties. Traceability, or the ability to obtain product information and its transit along the supply network, has emerged as a critical requirement for product quality and safety. RFID can help to eliminate inventory discrepancies and improve demand forecasting accuracy. These savings will help to reduce inventory expenses as well as other costs associated with holding and ordering in the SC [10]. RFID is used to monitor and trace products; as a result, it can effectively and reliably manage forgery and the distribution of poor products across the supply chain, boosting consumer confidence and ensuring food quality and safety [41]. RFID sensor tags can be used to assess the goods condition in transit. Fast-degrading products should be sent to nearest consumers, while products with a longer shelf life can be delivered to distant locations [14]. Consumers may follow fresh products back to the whole supply chain, which provides essential information about transportation, handling, processing, and packaging all the way up to the producer level. [6].

The capacity of RFID to record and communicate real-time data all over the supply chain generated information about customers that help organizations enhance their products and services. [10]. When RFID technology is used in a value chain, it is likely to boost decision-making reliability and real-time data sharing among members of the supply chain. As a result, all stakeholders will have increased trust and dedication, providing value and reciprocal interest to all involved parties [10]. The use of RFID in cold chain vehicles enhances shelf life, food quality, and safety while also affecting the two important parameters of storage time and temperature, all of which are detrimental to the freshness of agricultural products [8]. A digitally traceability system for management and customers was designed to provide not only real-time monitoring of tagged items but also food safety and quality of fragile agro food all across supply chain [42].

3 Proposed System Architecture

There are certain stages in our proposed framework which begins with the producer and conclude with arbitrary. We integrated Online/offline RFID implication throughout supply chain to validate the authenticity of the goods by tracking, tracing and so on.

Step 1: In the initial stage in supply chain operation all node needs to register into the block chain network using Hyperledger Fabric technology.

Step 2: Most vital part throughout supply chain is administration of RFID tagged goods which can be easily controlled and monitored by control server. This process also ensures the specific value added to the goods at each stage of AFSC. Furthermore, during dispatching of produced foods by producer if used RFID then it helps to prevent the huge amount of food wastages due to perishability of fresh foods.

Step 3: As per requirement of Agri- food industry the produced yields were shipped to processing unit by all the intermediaries such as small vendors, agents etc. Each container of shipped yields has certain information which can easily crossly checked by tagged RFID to check their shelf live or this produced yields belongs to which agent and so on. In this way every minute details can be easily updated and monitored throughout the AFSC by control server (Fig. 1).

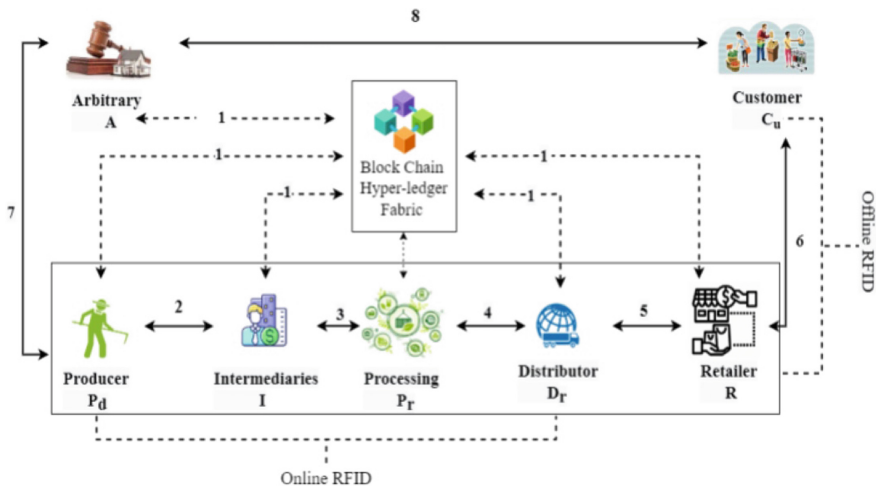


Fig. 1. Agri-food Supply chain using RFID and Blockchain

Step 4: After the receiving the yields processing units begins sorting, washing, packing, and make the products ready for consumption. In this stage while packaging each of the goods tagged with RFID which stored specified information. Thereafter, all finished goods shifted to their warehouses as per the appropriate temperature.

Step 5: Once they got the confirmation for the order the finished goods start getting distributed by various distributors from the warehouses of the processing units. In this stage each of the specified cold supply chain vehicles tagged with RFID which helps to monitor the traffic, tracking, tracing and route by which it get to be delivered to retailer. Each of the information shared throughout the shipment of goods to retailer get automatically updated by the control server.

Step 6: As per the consumption demands, the end user purchase the finished goods from nearby retailers or convenience stores. In this stage each of the vital information can be easily shared or obtained by end user, just need to scan the RFID tagged and they can get all the information such as perishability, shelf life, and so on, about the goods which are monitored through control server throughout the supply chain.

Step 7: The authenticity of the finished goods is not up the mark. Then the end user can easily report this to the arbitrary and hereafter, arbitrary investigate to find out at which stage the product is counterfeited and required information is rectified by the help of control server. Throughout this operation the various associated barriers can easily be reduced by implication of online/ offline RFID in AFSC.

3.1 Proposed Method

Step 1

$m_a = k_A$ (*Private key*)

$K = k_A * G$ K is a *Public key* created from k_A
 G -Key generator



BC Address $x_i^1 || x_i^2 \dots \dots x_i^n \in \{X\}$

Step 2

m_a assign a BC Address x_i^1 to $IC_i, IC_{i+1} \dots \dots IC_{i+n}$

Step 3

m_a can also assign another BC Address $x_j^1 \in \{X\}$ to $IC_j, IC_{j+1} \dots \dots IC_{j+n}$
 In fact, $IC_i \approx IC_j$

Where, IC_i - First version
 IC_j - Second version } Same Part-Number

Step 4

Blockchain Address x_i^1 create trust chain on Module P_i through Smart Contract
 SC for $SC_{m_a}, m_a \in IC_i, IC_{i+1} \dots \dots IC_{i+n}$
 Blockchain Address x_j^1 create trust chain on Module P_j^1 through Smart Contract
 SC for $SC_{m_b}, m_b \in IC_j, IC_{j+1} \dots \dots IC_{j+n}$
 Blockchain Address x_k^1 create trust chain on Module P_r^n through Smart Contract
 SC for $SC_{m_n}, m_n \in IC_k, IC_{k+1} \dots \dots IC_{k+n}$

Create Smart Contract in DAPP and generate a Private Blockchain Network where all BC Address can Verifies via trust chain.

3.2 Pseudocode Algorithm for Smart Contract

Algorithm: Procedure to create Smart Contract

INPUT: θ , Producers's Address (addrProducer), Processing Information (P_r Info), Smart Contract Template CMC (CreateSC)

OUTPUT: Blockchain Address (BCaddr), Generate Smart Contract

1 θ is the Trust Chain operation of all BC Address

2 P_1, m_2, m_n – Producers address participating in this contract ,
 $P \in m_1, m_2, \dots, m_n$

3 If BC Address is in addrProducer list, then

4 Specify Owner as addrProducer

5 Register product Info on the BCaddr

6 End

7 Create private keys(k_A) randomly 256 times with the binary digits of a random private key to use in a blockchain wallet.

8 Producer creates a private key $k_A, P_{d_n} = \text{Private key } (k_A)$

9 k_A is the private key, G is a constant point called the generator point, and K is the resulting public key (K)

10 K is a Public key created from k_A

11 $K = k_A * G$ G -Key generator

12 BC Address created from public key K
 Blockchain address with a string of digits and characters. Addresses produced from public keys consist of a string of numbers and letters, beginning with the digit 1.

13 BC Address $x_i^1 || x_i^2 \dots \dots x_i^n \in \{X\}$

14 P_d - Producers assign to BC Address

15 P_{d_1} assign a BC Address x_1^1 to $P_{d_1}, P_{d_2} \dots \dots P_{d_n}$

16 P_{d_2} assign a BC Address x_2^1 to $P_{d_2}, P_{d_2} \dots \dots P_{d_n}$

17 P_{d_n} assign a BC Address x_n^k to $P_{d_k}, P_{d_{k+1}} \dots \dots P_{d_{k+n}}$

18 P_d can also assign another Bcaddr

29 $x_j^1 \in \{X\}$ to $P_{d_2}, P_{d_2} \dots \dots P_{d_n}$

20

21 CreateSC in DAPP and generate a Private Blockchain Network where all BC add can Verifies via trust chain (θ).

22 Blockchain Address x_1^1 create trust chain on processor P_r through Smart Contract

23 SC for $SC_{P_d}, P_d \in P_{d_1}, P_{d_2} \dots \dots P_{d_n}$

24 Blockchain Address x_2^1 create trust chain on processor P_r^1 through Smart Contract

25 SC for $SC_{P_{d_2}}, P_{d_2} \in P_{d_2}, P_{d_2} \dots \dots P_{d_n}$

26 Blockchain Address x_k^n create trust chain on processor P_r^n through Smart Contract

27 SC for $SC_{P_{d_n}}, P_{d_n} \in P_{d_k}, P_{d_{k+1}} \dots \dots P_{d_{k+n}}$

28 end

29 end

30 end

31 else

32 Show an Error and Revert Contract

33 End

3.3 Authenticate Product Via RFID in Blockchain

RFID in blockchain technology make a secure platform in between whole supply chain and the blockchain framework produces the h module traceability in the supply chain. All the actors in supply chain operation countries or track the RFID attack modules by using the blockchain app. Register the product in the blockchain ledger through the smart contract and a smart contract storing transaction history of each product. RFID reader can scan the products batch number and get the information from the blockchain ledger and storing information to the blockchain ledger. So, it's easy to detect the counterfeit product. Originality of the products automatically verified using a blockchain ledger [43].

RFID Tags:

Product information stores in RFID tags which mounted each packet and data store by registering as a smart contract. Or if RFID tags are scanned in every node in the supply chain operation from producer to retailer.

There are two advantage of RFID reader.

1. UHF reader at batch of modules in blockchain ledger.
2. All products can trace and track in supply chain operations.

Smart contract makes the mechanism of authentication by create trust between customer and the whole supply chain operation. It's made the security and transparency in between customer and whole supply chain operation; we designed the smart contract algorithm to trace the product by registration in the blockchain network. Producers register the product information in the distributed ledger and update transaction in every node following the supply chain. Product ID attach in last transaction history customer, distributor, retailer, processor can verify the transaction of models.

4 Conclusion

We have proposed privacy preservation and efficient mutual validation approach for supply chain operation. In our system architecture each RFID inbuilt product combined with a blockchain and each transaction in supply chain scrutinize and define the process. We stored each product information into the blockchain network because of customer can easily validated the product via blockchain and easily can check that the product is original or duplicate. We used arbitrary technique, arbitrary can also check legitimate of any nodes in any point of logistic process by providing protection of system from producer to customer. Used ECDA secure smart contract algorithm process to make sure the security in the whole system. Encrypted every information before process into the blockchain network and make smart contact based on ECDA process for every communication node in the whole logistics system.

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