# Reliability Enhancement and NFT Data Structure Design for Blockchain-Based Traceability System for Large-Value Commodities

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The aim of this thesis is to propose a reliability enhancement method for blockchain-based traceability system for large-value commodities, and to design the data structure as NFT (non-homogenized tokens), which highlights the uniqueness and uniqueness of the NFT in order to improve the trustworthiness and reliability of the system. Through a combination of user-submitted proposals, evaluation platforms, and proof monitoring centers, the system realizes the traceability and supervision of large-value commodities and ensures the uniqueness and anti-counterfeiting of each commodity using the NFT data structure. The system utilizes the decentralized nature of blockchain and the automated execution of smart contracts to improve the transparency, security, and credibility of traceability for large-value commodities.

# I. Introduction

The application of blockchain traceability system in the fields of food safety, drug traceability, and luxury goods traceability has achieved certain results. Domestic technical research focuses on using the decentralized, tamperproof and traceable characteristics of blockchain, while paying attention to the application of smart contracts and cryptography technology. In the application field, domestic enterprises have begun to use blockchain to realize food traceability and ensure the safety and quality of food. Foreign countries have also conducted extensive exploration in technical research, proposing solutions to improve the performance and scalability of blockchain, and combining emerging technologies such as artificial intelligence and the Internet of Things. In the application field, foreign enterprises have used blockchain technology to realize the whole process of traceability from the farm to the dining table to ensure the quality and safety of food. In the future, blockchain traceability systems are expected to develop further and combine with other emerging technologies to meet the traceability needs of different industries. However, challenges such as large-scale data storage and processing, information accuracy and consistency, and the balance between privacy protection and information sharing still need to be addressed to ensure the reliability and security of the system.

Traceability of large-value commodities is of great significance in protecting consumer rights and interests, combating counterfeit and shoddy goods, and maintaining market order. However, the traditional traceability system has problems such as information asymmetry and data tampering, which makes it difficult to ensure reliability.

This thesis proposes a blockchain-based traceability system for large-value commodities and designs the data structure as NFT, which solves the trust and supervision problems in the traditional system by the decentralized characteristics of blockchain and the automated execution of smart contracts, and highlights the uniqueness and uniqueness of NFT to enhance the reliability of the system.

## II. Introduction to NFT Technology

Non-homogenized tokens (NFT) are blockchain-based digital assets with characteristics such as uniqueness, irreplaceability, and verifiability. NFT can be used to record information about a user's social interactions and asset ownership, enabling decentralized data storage and transactions.

NFT accordingly inherits the underlying logic of blockchain technology such as decentralization, distributed bookkeeping, smart contracts and other basic features such as openness, transparency, immutability, traceability, etc., as well as the typical features of non-homogenized assets: uniqueness, independence and scarcity.

NFT casting process: the user first selects OpenSea, Bigverse and other trading platforms, each platform will support a variety of blockchain, NFT is deployed to the selected blockchain through a smart contract, the blockchain only stores the NFT, and its corresponding digital assets are not chained and stored in other locations, NFT is equivalent to the ownership certificates of the digital assets, and the smart contract will record the asset's NFT is equivalent to the ownership certificate of the digital asset, and the smart contract will record the information of the asset such as token ID, original resource storage location, etc. Figure 1 below
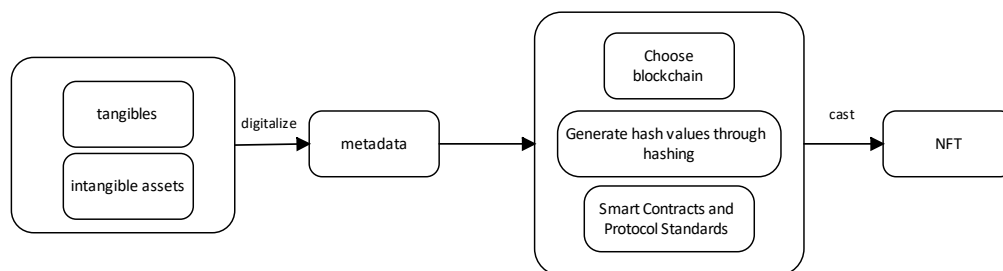


Fig. 1 NFT casting process

$$NFT = (ID, Metadata, Owner, NftLabel)$$

The above formula shows that the essence of NFT is a set of data collection generated based on blockchain technology, enjoying the logic of blockchain technology, and stored on the blockchain. The data collection is characterized by symbols (e.g. pixel avatars, digital cats,

artworks, collectibles, etc.), and the kernel is a string - a hash value. The hash value of NFT encapsulates the metadata of the thing of value, the transaction data, and the related equity data. And the blockchain data comes with a timestamp, which is jointly verified and recorded by consensus nodes, and cannot be tampered with or forged. As a result, NFT is characterized as unique, indivisible, tamper-proof, and highly verifiable and traceable. Such features allow NFT to be equated to a digital proof of property rights for things of value, recording the ownership and transaction records of things of value, thus realizing the affirmation of rights and circulation of things of value within the meta-universe, as well as between the real society and the virtual world. However, as a representation of a technological structure for recording, transmitting, and storing, the data structure of NFT is inherently compatible with a narrative approach, with the opportunity for a vast ecology of content to emerge. NFT is more than just a means of storing and transmitting value in the sense of political economy, but it has the potential to evolve in the direction of a social medium.

# III. Technology Extension and Value Attributes of NFT (Status Quo)

## 3.1 Digital collection traceability

The application scenarios based on NFT traceability are mainly in the circulation and trading of artworks and collectibles. By digitizing and transforming artworks or collectibles into NFT tokens, each work can have a unique traceability record. For example, on an NFT platform, artists can transform their works into NFTs and record the creation process, ownership information and transaction history of the works in the metadata. Such traceability can help verify the authenticity and copyright ownership of the work and provide more transparency and trust in the trading of artworks.

For example, an artist publishes a digital artwork on the NFT platform. This NFT will contain information such as the metadata of the work, a unique Token ID and a smart contract address. When the work is resold or used, this information is recorded on the blockchain, irrevocably displaying the artwork's traceability and transaction history. Purchasers can verify this information to confirm the authenticity of the work and the authorization of the artist.

This application scenario based on NFT traceability can solve some problems in traditional art transactions, such as authenticity verification of works, copyright protection and transaction history tracing. At the same time, the uniqueness and non-replicability of NFT can also reduce the risk of artwork piracy and infringement, and enhance the revenue and credibility of artists.

## 3.2 Identity traceability

By digitizing and converting personal identity and related information into NFT tokens, each individual can have a unique record of identity traceability.

For example, in an identity authentication platform based on NFT

traceability, an individual can transform his or her identity information and authentication records into NFT and record the individual's proof of identity, educational background, work experience, and other relevant authentication information in metadata. Such an identity traceability feature can help verify an individual's true identity and authentication information, and provide more transparency and credibility to identity authentication.

For example, a job seeker creates his or her identity NFT on the NFT Authentication Platform. This NFT will contain information such as the individual's identification, educational background, and work history. When a job seeker applies for a job, this information can be verified and the individual's identity traceability and authentication history can be displayed tamper-proof on the blockchain. Employers can verify this information to confirm the true identity and relevant certifications of job applicants.

This NFT traceability-based identity authentication application scenario can solve some of the problems in traditional identity authentication, such as identity forgery, information tampering and authentication fraud. At the same time, the uniqueness and non-replicability of NFT can also reduce the risk of identity theft and impersonation, and enhance the security and trust of personal identity.

## 3.3 Commodity traceability

By digitizing goods and converting them into NFT tokens, each item can have a unique traceability record, enabling traceability and transparency of goods.

For example, a farm can convert its agricultural products into NFT and record information about the product's planting and breeding process, picking time, etc. in the metadata. Such a traceability feature can help consumers verify the authenticity of the product, trace its origin and production process, and provide trust in the quality and safety of the product. Consumers can scan the QR code on the NFT or access the information on the blockchain to obtain detailed product traceability information to make more informed purchasing decisions.

Similarly, for the luxury goods industry, NFT traceability can be used to ensure product authenticity and prevent counterfeiting. Brands can transform each product into an NFT and record information such as the manufacturing process, source of raw materials and production batch of the product in the metadata. Consumers can verify the information on the NFT to confirm the authenticity of the product and gain trust in the brand.

In addition, NFT traceability can also be applied to other commodity sectors, such as electronic products, automobiles, and luxury goods. By transforming commodities into NFTs and recording key information on the blockchain, consumers can trace the production, distribution and use of products to better understand their quality and history.

Application scenarios based on NFT traceability can solve some of the problems in traditional commodity trading, such as product authenticity verification, prevention of counterfeiting, and tracing the origin and production process of products. At the same time, the non-tamperability and transparency of NFT can also enhance consumers' trust in commodities and promote fair trade and brand development.

## 3.4 Copyright Traceability

The application scenarios based on NFT traceability are not limited to artworks and collectibles, but can also be applied in the field of copyright traceability. By transforming digital content into NFT tokens and recording copyright information, transaction history, etc. in metadata, each work can have a unique traceability record, thus providing more transparency and trust.

For example, a creator can convert his digital content, such as musical works, movies, literary works, etc., into NFTs and record the creation process, copyright information, transaction history, etc., in the metadata. When the work is licensed, resold, or used, this information is recorded on the blockchain, irrevocably showing the traceability and transaction history of the work. Purchasers or users can verify this information to confirm the copyright ownership and legitimacy of the work.

This application scenario based on NFT traceability can solve some problems in traditional copyright protection, such as copyright disputes,

piracy and infringement of works. Through the immutability and transparency of blockchain technology, it can ensure that the copyright ownership of works is effectively protected and reduce the possibility of copyright disputes. At the same time, the uniqueness and non-replicability of NFT can also reduce the risk of piracy and infringement of works, providing better revenue and protection for creators.

In conclusion, the application scenario based on NFT traceability has a broad development prospect in the field of copyright protection. By utilizing the characteristics of blockchain technology, it can provide more transparency, trust and protection measures for copyright traceability of digital content. This application scenario will promote the innovative development in the field of copyright protection and provide creators and users with a better copyright protection and transaction environment.

# IV. Advantages over pure blockchain

Refined uniqueness: each NFT has a unique identifier and attributes that can ensure the uniqueness of each commodity in the traceability system. Compared to blocks in a traditional blockchain, where each block represents a transaction record over a period of time, NFTs can more accurately represent the specific information and attributes of each commodity, improving the uniqueness and traceability accuracy of the commodity. For example, a jewelry company could use NFT to record the unique attributes and history of each piece of jewelry, ensuring that each piece of jewelry has a unique identifier in the system.

Higher Flexibility and Scalability: NFT as non-homogenized tokens, each NFT has unique attributes and values. This allows the traceability system to create and manage different types of NFTs according to different types of commodities and needs. Compared to blocks in traditional blockchain, NFTs are more flexible and scalable, and can better adapt to the traceability needs of different industries and commodities. For example, an agricultural company can create unique NFTs for each agricultural product to record information about its cultivation, processing and transportation.

More intuitive storage of traceability information: NFT can store the traceability information of commodities directly in their attributes, forming a complete and visualized traceability record. Compared with the traditional blockchain where the traceability information is stored in the transaction records of the blocks, NFT's traceability information storage is more intuitive, easy to access and understand, making it easier for consumers to trace the origin, production process and supply chain information of the goods. For example, a winery can store the year of production, grape variety and place of production of each bottle of wine as an attribute of NFT, and consumers can scan the NFT to obtain detailed traceability information of that bottle of wine.

Higher Transaction Efficiency: Due to the non-homogenized nature of NFTs, the transaction of each NFT can be carried out independently without waiting for the transaction confirmation of the whole block. This improves the efficiency of commodity transactions in the traceability system.

Compared to the confirmation time required for the entire block in traditional blockchain, the independent transaction performance of NFT is higher, enabling faster transfer and trading of goods. For example, an art gallery can store the traceability information of each piece of artwork as an NFT and conduct transactions of artwork through the NFT, improving transaction efficiency and convenience.

# V. Evaluation system design

In the blockchain-based traceability system for large-value commodities, the system design is the key to ensure the reliability of the system. The design scheme of the system is described in detail below, and the design is shown in Figure 2 below:
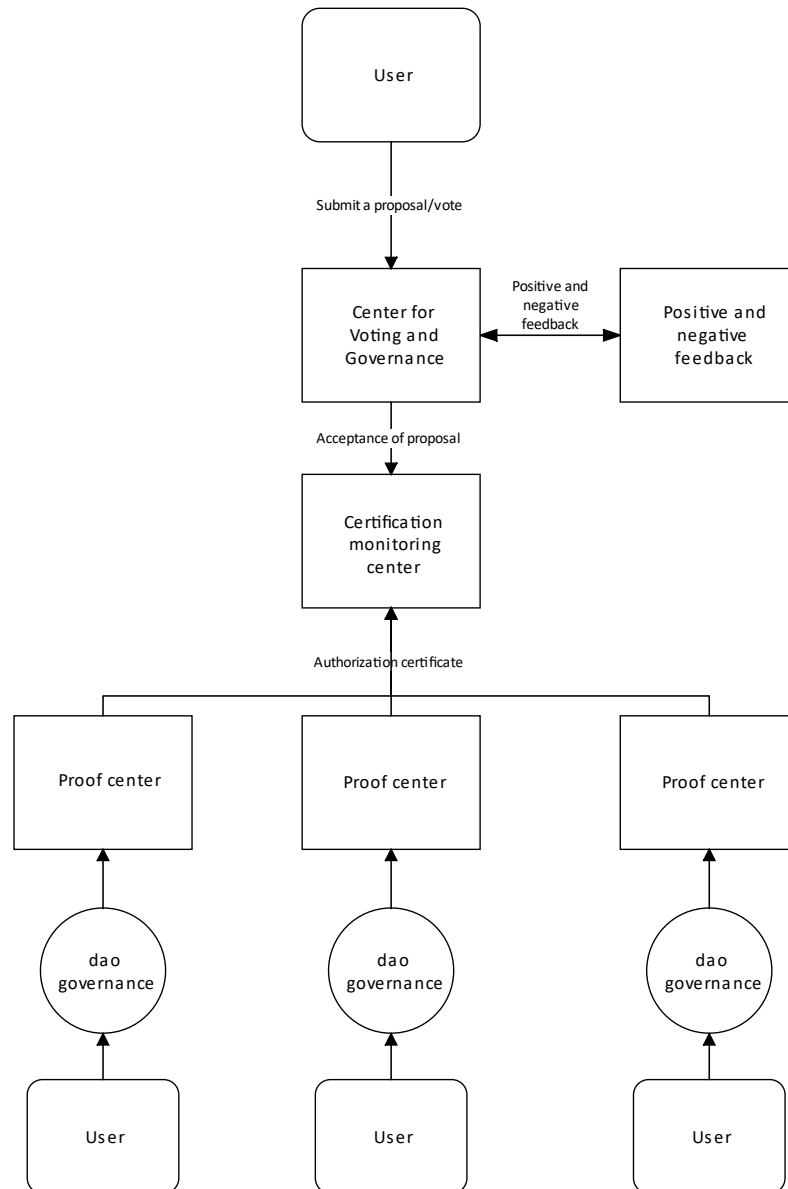
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                        ┌──────────┐
                        │          │
                        │   User   │
                        │          │
                        └────┬─────┘
                             │
                    Submit a proposal/vote
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┌────────────────┐  Positive and  ┌──────────────┐
│   Center for   │    negative    │ Positive and │
│   Voting and   │◄──feedback────►│   negative   │
│   Governance   │                │   feedback   │
└───────┬────────┘                └──────────────┘
        │
  Acceptance of proposal
        │
        ▼
┌────────────────┐
│  Certification │
│   monitoring   │
│     center     │
└────────────────┘
        ▲
  Authorization certificate
        │
  ┌─────┴──────────────┬──────────────────┐
  │                    │                  │
┌───────────┐    ┌───────────┐     ┌───────────┐
│  Proof    │    │  Proof    │     │  Proof    │
│  center   │    │  center   │     │  center   │
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 │  User  │       │  User  │        │  User  │
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Fig. 2 System design

## 5.1 Submission of proposals by users

Users can submit proposals for traceability of large-value commodities through the blockchain platform. The proposal includes details of the commodity, production process and supply chain information. Each proposal generates a unique proposal ID on the blockchain for subsequent query and verification. To increase the credibility of the proposal, users can provide relevant information and proofs, such as supplier certification and quality inspection reports.

## 5.2 Evaluation platform

In order to ensure the fairness and transparency of traceability information, the system has set up an evaluation platform, which is composed of users. Users can evaluate and give feedback on proposals and traceability results. The evaluation results will be recorded on the blockchain to ensure that they cannot be tampered with. Users can make comments and scores, and provide relevant evidence and supporting materials. The evaluation platform can increase the transparency of the system, as well as the ability to involve consumers in the system and increase their trust.

## 5.3 Certification Monitoring Center

In order to ensure the reliability of the system, the system has established a Proof Monitoring Center, which consists of multiple distributed proof centers made up of retail customers. The task of the Proof Monitoring Center is to verify the authenticity of the proposal and the reliability of the commodity traceability to ensure the credibility of the system and the compliance of the commodities. The Proof Monitoring Center, through the automated execution of smart contracts, can audit proposals and conduct field inspections and sampling verification of various links in the supply chain. Only after the passing rate of each proof center meets certain requirements will the Proof Monitoring Center

grant traceability certification to the commodities.

## 5.4 NFT Data Structure Design

In order to ensure the uniqueness and anti-counterfeiting of each commodity, the system designs the traceability information of commodities as NFTs (non-homogenized tokens). Each NFT represents a unique identifier of a commodity, which contains detailed information of the commodity, production process and supply chain information, etc. NFTs are managed through smart contracts to ensure their uniqueness and anti-counterfeiting. Each NFT has a unique identifier that can be queried and verified for traceability through the blockchain platform.

# VI. System implementation

## 6.1 Building a blockchain platform

When realizing a large-value commodity traceability system, you first need to choose a suitable blockchain platform to build the system. Currently, commonly used blockchain platforms include Ether, Hyperledger Fabric, EOS, and so on. Choosing a suitable blockchain platform takes into account factors such as the security, scalability and performance of the system. When building a blockchain platform, you need to build blockchain nodes, deploy smart contracts, and configure relevant consensus algorithms and encryption algorithms to ensure the security and reliability of the system.

## 6.2 Designing the User Interface

In order to facilitate the participation of users in the traceability system for large-value commodities, a user-friendly interface needs to be designed. The user interface should have a good user experience so that users can easily submit proposals, make evaluations and view traceability results. The user interface should have a simple and clear layout, provide clear navigation and operation guidelines, and at the same time provide real-time updated data display and interactive functions.

## 6.3 Realization of the evaluation platform

The evaluation platform is a platform for users to evaluate and give feedback on proposals and traceability results. Through the logic of smart contract, the functions of the evaluation platform are realized, including evaluation submission, evaluation result record and query. Users can view the details of the proposal, evaluation feedback and historical traceability records of the supply chain on the evaluation platform. Evaluation results will be recorded on the blockchain to ensure the transparency and non-tamperability of the evaluation.

## 6.4 Establishment of the Certification Monitoring Center

The Proof Monitoring Center is the organization in the system responsible for verifying the authenticity of proposals and the reliability of commodity traceability. The Proof Monitoring Center consists of multiple distributed proof centers made up of retailers to supervise and manage the review of proposals and the reliability of commodity traceability through the automated execution of smart contracts. The Proof Monitoring Center can view and audit the progress of proposals through the blockchain platform, and evaluate and supervise all aspects of the supply chain. The Proof Monitoring Center can also conduct on-site inspections and sample verification to ensure that the origin and quality of goods meet standards.

## 6.5 NFT Data Structure Design

The traceability information of the commodities is stored as NFTs, and each NFT represents a unique identifier of a commodity. The NFTs contain detailed information about the commodity, the production process, and the supply chain information, and are ensured to be unique and anti-counterfeiting through smart contracts. Each NFT has a unique identifier that can be queried and verified for traceability through the blockchain platform. The data structure design of the NFT needs to take into account the attributes of the commodity and the way the traceability information is stored in order to achieve transparent and trustworthy traceability.

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