Classification Framework of Real World Assets Tokens

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Abstract

A. Strengths of the Framework's Exhaustiveness with a Matrix 2x2

The framework utilizes the fundamental dimensions of tangibility (tangible vs. intangible) and fungibility (fungible vs. non-fungible) alowing to create a 2 :2 Matrix.

These are core characteristics that can be applied to almost any asset, providing a robust foundation for classification.

By combining these two dimensions, the framework effectively creates four primary categories:

1. Fungible Tangible Tokens
2. Non-Fungible Tangible Tokens
3. Fungible Intangible Tokens
4. Non-Fungible Intangible Tokens

These categories, as demonstrated by the numerous examples provided below, are capable of encompassing a wide array of real-world assets that can be tokenized.

The document offers a rich set of examples within each category, ranging from commodities and real estate to financial instruments and intellectual property. These examples illustrate the practical applicability and breadth of the real world asset token classification system.

B. Inclusion of Digital Currencies

The document explicitly incorporates digital currencies, including stablecoins and CBDCs, within the "Fungible Intangible Assets" category. This is crucial in the context of tokenized assets and demonstrates the framework's adaptability to evolving asset classes.

C. Hybrid and Semi-Fungible Considerations

The framework acknowledges the existence of "Hybrid/Semi-Fungible Implementations" and mentions standards like ERC-1155. This shows an awareness of assets that may not neatly fit into strict fungible or non-fungible categories and provides flexibility depending on use cases.

D. Focus on Technical Implementation

The framework's focus on "technical implementation characteristics" rather than solely financial attributes makes it relevant across various technical contexts and blockchain platforms.

E. Nuances and Potential Considerations for Absolute Exhaustiveness

Evolving Asset Landscape: The document itself acknowledges that the tokenization space is rapidly evolving. While the current framework is comprehensive, entirely new types of assets or hybrid asset forms could emerge in the future that might require slight extensions or refinements to the categories. However, the fundamental dimensions are likely to remain relevant.

Granularity within Categories: While the high-level categories are exhaustive, one could argue that within each category, further sub-categorization might be possible based on more specific technical or legal characteristics. However, for a general classification framework, the current level of granularity appears appropriate and avoids unnecessary complexity.

Edge Cases and Blended Assets: There might be edge cases or highly complex "blended" assets that could be argued to straddle multiple categories simultaneously. However, the framework's flexibility and the concept of hybrid implementations likely allow for handling most of these scenarios by classifying the dominant characteristics or components of such assets.

I. Real World Asset Token Classification Matrix 2x2

This classification system designed to assist entities innovating in the tokenization market. This system is technologically neutral and aims to provide a robust framework for categorizing asset types. It employs an advanced 2x2 matrix that leverages two fundamental dimensions: tangibility (tangible vs. intangible) and fungibility (fungible vs. non-fungible).

This structured approach allows for a clearer and more precise classification of assets, ensuring a comprehensive understanding of their characteristics and potential applications in the tokenization space.

A. Tokenized Real Tangible Assets

1. Fungible Tangible Tokenized Assets

Definition :

Physical assets with interchangeable units and having the same characteristics that are represented digitally through divisible tokens issued within a distributed ledger systems.

Asset Categories:

Commodities: Precious metals (gold, silver), agricultural products (wheat, corn)

Energy Resources: Oil, natural gas, renewable energy units

Standardized Manufacturing Products: Industrial materials, mass-produced goods

Bulk Materials: Construction materials, raw industrial inputs

Fiat Currency: Stabelcoins, Central Bank Digital Currencies (CBDCs)

Token Development Standards:

These assets leverage token development standards such as ERC-20 or ERC-1400 ERC-1400 extends ERC-20 by introducing features tailored for regulated assets on Ethereum, FA2 on Tezos, Algorand Standard Assets (ASA) on Algorand, Stellar assets and Soroban tokens.

2. Non-Fungible Tangible Tokenized Assets

Definition:

Physical assets with non interchangeable units having distinct characteristics that are represented digitally through divisible tokens issued within a distributed ledger systems.

Asset Categories:

Real Estate: Land parcels, buildings, construction rights

Art and Collectibles: Fine art, antiques, memorabilia

Luxury Items: Jewelry, watches, limited edition products

Equipment and Infrastructure: Industrial machinery, transportation assets, energy production facilities

Token Development Standards:

These assets leverage token development standards such as ERC-721, ERC-1155 (for collections) on Ethereum, Flow NFT standard, Cardano CNFTs.

B. Tokenized Real Intangible Assets

1. Fungible Intangible Tokenized Assets

Definition:

Non-physical assets with interchangeable units having the same characteristics that can be represented by divisible tokens issued within a distributed ledger systems.

Asset Categories:

Financial Instruments: Equities, bonds, structured products

Credit and Rights Units: Carbon credits, renewable energy certificates, water rights

Service Units: Compute resources, storage units, subscription services

Revenue Streams: Royalty flows, dividend rights, interest-bearing assets

Token Development Standards:

These assets leverage token development standards such as ERC-20 or ERC-1400 ERC-1400 extends ERC-20 by introducing features tailored for regulated assets,

on Ethereum, FA2 on Tezos, Algorand Standard Assets (ASA) on Algorand, Stellar assets and Soroban tokens.

2. Non-Fungible Intangible Assets

Definition:

Non-Physical assets with non interchangeable units having distinct characteristics that are represented digitally through divisible tokens issued within a distributed ledger systems.

Asset Categories:

Intellectual Property: Patents, copyrights, trademarks

Licenses and Regulatory Rights: Operating licenses, broadcast rights, spectrum allocations

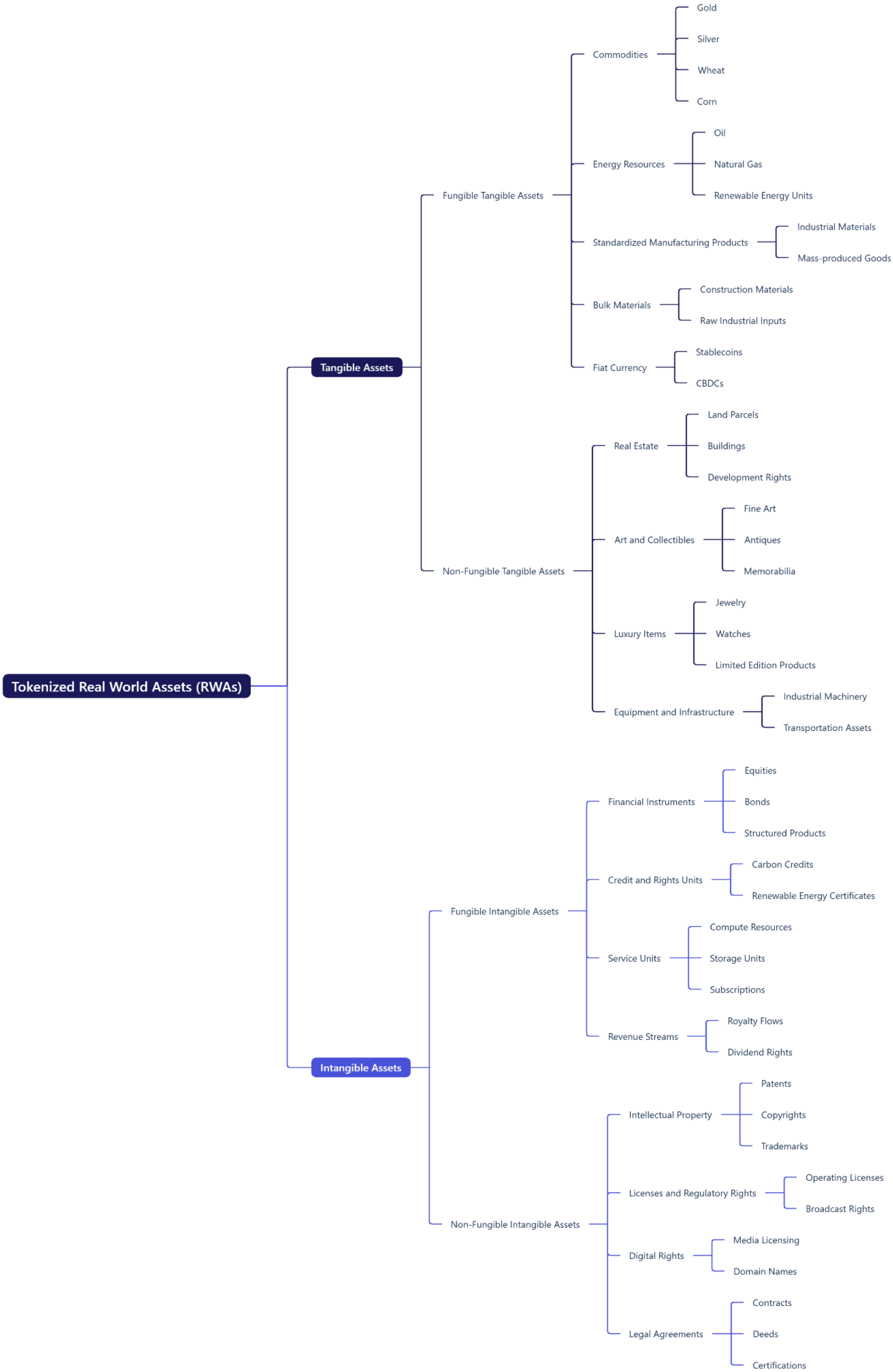
Digital Rights: Media licensing, digital content ownership, domain names

Legal Agreements: Contracts, deeds, certifications

Token Development Standards:

These assets leverage token development standards such as ERC-721, ERC-1155 (for collections) on Ethereum, Flow NFT standard, Cardano CNFTs.

C. Mind Map Tokenized RWAs Classification



II. Technical Implementation Architecture

A. Technical Challenges

The implementation of such tokenization systems faces technical challenges, including ensuring precise synchronization between the physical asset and its digital twin, establishing robust custody verification protocols, and designing efficient redemption mechanics and settlement processes.

Another technical challenges is the development of robust rights enforcement mechanisms and the automation of cross-border compliance processes.

B. Verification Requirements

Ensuring the reliability and accuracy of these assets necessitates the implementation of comprehensive physical auditing procedures alongside the deployment of oracle services. This dual approach facilitates seamless synchronization between tangible assets and their digital counterparts, thereby enhancing transparency, trust, and operational efficiency in asset management processes.

Smart contracts offer advanced features such as automated compliance and seamless regulatory reporting, facilitated through API integration with existing registries. Ensuring accurate regulatory status verification is crucial, while specific use cases like stablecoins require reliable reserve auditing and effective peg maintenance.

Central Bank Digital Currencies (CBDCs) introduce additional complexities, such as balancing privacy concerns, achieving interoperability with existing financial systems, and ensuring scalability to meet widespread adoption demands.

C. On-Chain Components

The on-chain components consist of two primary layers: the Token Layer and the Governance Layer.

1. Token Layer

At the heart of the Token Unit Layer lies a suite of base token smart contracts that serve as the building blocks for digital assets. These smart contracts are further enhanced with asset-specific extensions to accommodate unique characteristics, such as fungibility and tangibility. For instance, fungible tokens (like cryptocurrencies) and non-fungible tokens (NFTs) require distinct functionalities, and these extensions ensure that each asset type is tailored to its intended use case.

By incorporating these extensions, the Token Layer provides a flexible framework capable of adapting to a wide array of asset classes, from digital art and collectibles to real estate and financial instruments.

Its adaptability to various asset types ensures that businesses and developers can leverage tokenization to unlock new opportunities across industries. From streamlining supply chains to democratizing access to investment opportunities, the possibilities are vast and transformative.

a. Asset Metadata Standards and Distributed File Storage Solutions

Metadata plays a critical role in defining the attributes and identity of digital assets. The Token Layer includes standardized frameworks for asset metadata, ensuring consistency and interoperability across platforms. These standards enable clear and precise descriptions of assets, facilitating better understanding and usability.

In addition to metadata frameworks, efficient distributed file storage solutions are integrated within this layer to optimize data management. By leveraging advanced storage mechanisms like Filecoin or IPFS, the Token Layer ensures that metadata is stored by maintaining accessibility.

b. Ownership Registries and Transfer Mechanisms

Ownership is a cornerstone of any asset management system, and the Token Layer provides robust mechanisms to manage ownership registries identifying wallets holding the tokens recored on a distributed leger. These registries maintain an accurate and transparent record of asset ownership, reducing the risk of disputes and enhancing trust among stakeholders.

Furthermore, seamless transfer processes are embedded within this layer to enable efficient exchange of assets between parties. Whether it's a simple transaction or a complex transfer involving multiple intermediaries, the Token Layer ensures that ownership changes are executed securely and without friction.

c. Token Reserve verification

Token Reserve verification encompasses a range of mechanisms designed to ensure transparency and trust in financial or asset-backed systems including :

- Real-time attestation protocols which provide continuous validation of Token reserves
- Cryptographic proof of reserves, enabling secure and verifiable confirmation of holdings without exposing sensitive information.
- Third-party auditing integration plays a critical role in enhancing credibility by involving independent entities to validate reserve claims.
- Transparent on-chain reserve monitoring further strengthens accountability by leveraging blockchain technology to offer immutable and publicly accessible records of reserve status

2. Governance Layer

In the evolving landscape of blockchain technology, the Governance Layer emerges as a cornerstone for the secure and efficient management of digital assets. This critical component is designed to introduce asset-specific logic, enforce compliance protocols, and streamline the governance of on-chain transactions. By embedding innovative functionalities, the Governance Layer not only enhances operational efficiency but also ensures adherence to regulatory frameworks.

1. *Asset-Specific Logic and Compliance Rules*

At its core, the Governance Layer integrates asset-specific logic tailored to the unique requirements of each digital asset. This customization enables the precise execution of actions based on predefined parameters, ensuring that transactions adhere to the intended use cases. Moreover, compliance rules are hardcoded into the system, allowing organizations to align their operations with legal and regulatory standards. This built-in compliance mechanism mitigates risks associated with non-conformance and fosters trust among stakeholders.

Compliance is a cornerstone of any blockchain system aiming for widespread adoption. Standards like ERC-1400 provide frameworks for integrating regulatory requirements directly into token protocols.

2. *Automated Governance and Management Functions*

One of the most transformative aspects of the Governance Layer is its ability to automate governance and management processes. Through self-executing code, this layer facilitates decision-making, resource allocation, and operational oversight without the need for manual intervention. Automated governance not only reduces administrative overhead but also minimizes human error, creating a more reliable and transparent ecosystem for digital asset management. The Governance layer is a programmable smart contract from where all the governance needed functionalities and rules are coded (DAO, Smart Wallet …).

3. *Conditional Transfer Mechanisms*

Security and rule-based execution are paramount in blockchain transactions, and the Governance Layer addresses these concerns through conditional transfer mechanisms. These mechanisms ensure that asset transfers occur only when specific conditions are met, such as identity verification, payment confirmation, or compliance checks. By embedding these safeguards into the transaction process, the Governance Layer enhances security while maintaining a seamless user experience.

As blockchain technology continues to evolve, the Governance Layer will play an increasingly vital role in shaping the future of digital asset management. Its ability to integrate automation, and security positions it as a key enabler of innovation in decentralized ecosystems.

4. *Self-Custody Wallets:*

Self-custody wallets are essential tools for entities seeking to maintain full control over their digital assets without relying on third-party custodians. These wallets are typically categorized into cold storage solutions and warm or hot wallet solutions.

i. Cold Wallet Solutions:

Cold storage solutions, such as hardware wallets or offline paper/steel/metal wallets, prioritize security by keeping private keys disconnected from the internet, making them ideal for long-term storage of significant amount of assets

ii. Warm/Hot Wallet Solutions:

On the other hand, warm or hot wallet solutions provide more convenient access to funds by remaining connected to the internet, making them suitable for everyday transactions and active trading. Both options offer unique benefits and should be chosen based on the user's specific needs and risk tolerance.

- Mobile wallet applications
- Desktop wallet software
- Browser extensions and web wallets

iii. Multisignature Wallet Solutions :

Multisignature wallets are advanced digital tools designed to enhance the security and governance of cryptocurrency transactions. By requiring multiple authorized signatures to approve a transaction, these wallets mitigate the risks associated with single points of failure, such as compromised private keys or unauthorized access.

Built on blockchain technology, multisignature wallets ensure transparency, accountability, and trust among participants, making them an ideal solution for organizations, partnerships, or individuals seeking collaborative financial management.

Their programmable nature allows for customizable features, such as setting thresholds for approvals or integrating with decentralized applications, further solidifying their role as a cornerstone of secure and efficient digital asset management.

D. Off-chain components

Off-chain components serve as essential connectors between blockchain systems and the real world. These mechanisms ensure that physical assets, legal frameworks, and regulatory requirements can seamlessly integrate with decentralized ecosystems. Below are some of the most significant off-chain innovations:

1. Oracle Layer

In the rapidly evolving landscape of blockchain technology, oracles have emerged as a critical component for bridging the gap between decentralized networks and external data sources. By enabling smart contracts to interact with real-world external information, oracles unlock a wide array of use cases that extend the functionality of blockchain systems beyond their intrinsic capabilities. This document explores some of the key applications of oracles, including price feeds, market data connections, physical asset verification, regulatory compliance, and currency reserve attestation.

a. *Price Feeds and Market Data Connections*

One of the most prominent uses of oracles is in providing reliable price feeds and market data connections. In decentralized finance (DeFi), accurate and timely pricing information is essential for the proper functioning of applications such as lending platforms, decentralized exchanges, and derivatives markets. Oracles aggregate data from multiple sources to ensure that smart contracts have access to trustworthy and tamper-proof pricing information. This minimizes the risk of manipulation and enhances the overall security and reliability of DeFi protocols.

b. *Physical Asset Verification Systems*

Oracles also play a pivotal role in linking blockchain systems with physical assets in the real world. Through the use of IoT devices, sensors, and other verification mechanisms, oracles can confirm the existence, condition, or location of tangible assets. This capability is particularly valuable in industries such as supply chain management, where transparency and traceability are paramount. By integrating physical asset verification systems with blockchain technology, businesses can create immutable records that bolster trust and efficiency across their operations.

c. *Regulatory Compliance Verification*

As blockchain adoption grows, regulatory compliance has become a key concern for organizations operating in this space. Oracles can facilitate compliance by providing smart contracts with access to real-time regulatory data. This includes verifying identities for Know Your Customer (KYC) requirements, ensuring adherence to anti-money laundering (AML) standards, and monitoring transactions for suspicious activity. By automating compliance processes through oracle integration, companies can reduce operational overhead while maintaining alignment with legal frameworks.

d. *Currency Reserve Attestation for Stablecoins*

Stablecoins, which are digital assets pegged to a stable reserve such as fiat currency, rely heavily on transparency and trust. Oracles enable currency reserve attestation by delivering real-time verification of the reserves backing these digital assets. This process ensures that stablecoin issuers maintain adequate reserves to meet redemption demands, thereby fostering confidence among users. Through cryptographic proofs and third-party audits facilitated by oracles, stablecoin ecosystems can achieve greater accountability and resilience.

2. Bridging Physical and Digital Realities

Off-chain components serve as essential connectors between blockchain systems and the real world. These mechanisms ensure that physical assets, legal frameworks, and regulatory requirements can seamlessly integrate with decentralized ecosystems.

Below are some of the most significant off-chain innovations:

a. IoT Device Integration Framework

The Internet of Things (IoT) plays a crucial role in tracking and monitoring physical assets. IoT-enabled devices provide real-time data about an asset's condition, location, and usage, ensuring its digital representation remains up-to-date.

b. Third-Party Verification and Auditing Systems

Independent verification mechanisms are essential for ensuring that the physical asset corresponds to its on-chain token. These systems provide trust and transparency for all stakeholders involved.

c. Physical Custody Solutions

Secure storage and custody solutions are vital for safeguarding physical assets. These systems often include advanced measures such as biometric access controls, 24/7 monitoring, and insurance coverage to protect against theft or damage.

iv. Centralized Vaulting Systems:
- Bank-grade secure facilities with physical access controls
- Third-party custodial services with insurance coverage
- Specialized storage for specific asset classes (fine art, precious metals, etc.)
- High-security transport and handling protocols

v. Distributed Physical Custody:
- Multi-location storage with risk distribution
- Geographically diversified storage networks
- Distributed regional custody with local verification protocols
- Redundant physical storage systems with failover mechanisms

d. Custodial Waallet Solutions

Custodial wallet solutions provided by third parties encompass a range of secure and efficient options tailored to meet diverse needs.

i. Centralized exchange wallets which offer integrated storage solutions within trading platforms.
ii. Banking custody solutions that leverage traditional financial institutions for asset safeguarding.
iii. Institutional custody providers cater to large-scale entities requiring robust security and operational frameworks.

III. Technical Standards and Protocols in Blockchain Technology

In the rapidly evolving landscape of blockchain technology, technical standards and protocols play a pivotal role in ensuring interoperability, scalability, and security. These standards define the rules and structures for creating and managing digital assets, enabling seamless interaction across diverse platforms. This document delves into the primary categories of token standards, their use cases, and their significance in the broader blockchain ecosystem.

A. Token Standards: A Comprehensive Overview

Token standards are the backbone of blockchain-based asset management. They dictate how tokens—fungible, non-fungible, hybrid, or security-based—are created, transferred, and interacted with.

Technical standards and protocols are fundamental to the growth and maturity of blockchain ecosystems. From enabling seamless token transfers to ensuring regulatory compliance in security token offerings, these frameworks provide the structure necessary for innovation and adoption. As the blockchain industry continues to expand, evolving standards will remain at the forefront of shaping its future.

By understanding these foundational elements, developers, businesses, and regulators can better navigate the complexities of blockchain technology while unlocking its transformative potential.

Below is a detailed exploration of the major token standards currently shaping the industry.

1. Fungible Token Standards

Fungible tokens are interchangeable units of value, where each token is identical to another of the same type. These tokens are widely used for cryptocurrencies, stablecoins, and utility tokens.

Key standards include:

- ERC-20: The most widely adopted standard for fungible tokens on the Ethereum blockchain. It defines a set of rules for token creation and management, ensuring compatibility with wallets and exchanges.
- ERC-777: An advanced alternative to ERC-20, offering enhanced functionality such as operator controls and hooks for improved token handling.
- Tezos FA1.2: A fungible token standard specific to the Tezos blockchain, emphasizing flexibility and simplicity in implementation.

- Algorand ASA (Algorand Standard Assets): A versatile framework for creating fungible tokens on the Algorand blockchain, supporting features like atomic transfers and reconfigurability.
- Stellar Assets and Soroban Tokens: Stellar's robust framework for asset tokenization ensures both scalability and usability, while its new Soroban platform offers programmable smart tokens for diverse applications on the network.

2. Non-Fungible Token Standards

Non-fungible tokens (NFTs) represent unique digital assets that cannot be exchanged on a one-to-one basis. These are widely used for digital art, collectibles, and identity verification. Prominent standards include:

- ERC-721: The pioneering standard for NFTs on Ethereum, enabling the creation of unique tokens with distinct metadata.
- Flow NFT: A standard designed for the Flow blockchain, optimized for high-performance applications like gaming and digital collectibles.
- Cardano CNFTs (Cardano Non-Fungible Tokens): NFTs on the Cardano blockchain that leverage its native token capabilities for efficient creation and transfer.

3. Hybrid Semi Fungible Token Standards

Hybrid tokens combine the properties of fungible and non-fungible tokens, offering flexibility for use cases such as gaming assets or tokenized real-world items.

Key standards include:

- ERC-1155: A multi-token standard on Ethereum that supports both fungible and non-fungible tokens within a single smart contract, reducing deployment costs.
- ERC-3525 (Semi-Fungible Token): A newer standard enabling semi-fungibility, where tokens can transition between fungible and non-fungible states based on their usage.

4. Digital Currency-Specific Standards

As central banks explore Central Bank Digital Currencies (CBDCs) and other digital currencies gain traction, specialized standards have emerged to address their unique requirements:

- ISO 20022 Compliant Formats: These formats facilitate interoperability between CBDCs and traditional financial systems by adhering to global payment messaging standards.
- EIP-1850 (Conditional Tokens): A standard for creating tokens with conditional logic, often used in programmable finance.

5. Security Tokens

Security tokens represent ownership in real-world assets such as equity, debt, or real estate. They are subject to regulatory compliance, making their standards crucial for legal adherence and investor protection:

- ERC-1400: A comprehensive standard for security tokens on Ethereum, incorporating features like transfer restrictions, compliance checks, and partitioning for enhanced functionality.

B. Metadata Token Standards

Metadata standards play a critical role in ensuring interoperability, consistency, and efficiency in modern digital ecosystems. With the rapid evolution of technologies such as decentralized storage, blockchain, and central bank digital currencies (CBDCs), the need for robust and adaptable metadata frameworks has become increasingly apparent. Below, we examine some of the key metadata standards shaping the digital landscape.

1. IPFS/Filecoin for Decentralized Storage

The InterPlanetary File System (IPFS) and Filecoin represent innovative solutions for decentralized storage. IPFS is a peer-to-peer protocol designed to make the web faster, safer, and more open by enabling distributed file sharing. Filecoin complements IPFS by providing a decentralized marketplace for storage, incentivizing users to contribute unused storage capacity. Together, these technologies rely on metadata to catalog, retrieve, and verify files efficiently. Metadata ensures that files are uniquely identifiable and accessible across the decentralized network, enhancing scalability and reliability.

2. JSON-LD Schemas for Asset Characteristics

JSON-LD (JavaScript Object Notation for Linked Data) is a lightweight data-interchange format that enables the representation of structured data in a machine-readable way. It is particularly effective when used to describe asset characteristics in various domains, including digital assets, supply chains, and e-commerce. By embedding metadata within JSON-LD schemas, systems can achieve semantic interoperability, allowing diverse platforms to understand and process data seamlessly. This standard is especially valuable in contexts where assets need to be described with precision and linked to other datasets.

3. ERC-721 Metadata Extension for Enhanced Attributes

The ERC-721 standard is fundamental to the creation of non-fungible tokens (NFTs) on blockchain networks like Ethereum. The ERC-721 Metadata Extension expands upon this standard by enabling enhanced attributes for NFTs. This extension allows developers to define detailed metadata for each token, including properties such as name, description, image URLs, and additional attributes specific to the token's use case. This enriched metadata provides a richer user experience and facilitates the integration of NFTs into various applications, from gaming to digital art marketplaces.

4. ISO 20022 Financial Messaging Standards for CBDCs

In the financial sector, ISO 20022 has emerged as a global standard for electronic data interchange between financial institutions. With its flexible and extensible framework, ISO 20022 is increasingly being adopted in the development of central bank digital currencies (CBDCs). This standard enables the seamless exchange of payment instructions, account details, and transaction metadata across diverse financial systems. By adopting ISO 20022, CBDCs can achieve greater interoperability with existing financial infrastructures while supporting advanced functionalities like programmable money and cross-border payments

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ISO 20022 Financial Messaging Standards

ERC-20 Token Standard

ERC-721 Non-Fungible Token Standard

ERC-1155 Multi-Token Standard

ERC-777 Token Standard

ERC-3525: Semi-Fungible Token

ERC-1400 : Security Token

Flow NFT Standard

Cardano CNFTs (Cardano Non-Fungible Tokens)

Algorand Standard Assets (ASA)

FA2 on Tezos

Soroban tokens

EIP-1850 (Conditional Tokens)