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Non-Fungible Tokens (NFTs)

Briefing Paper

National Archives and Records Administration

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Introduction

The National Archives and Records Administration, Office of the Chief Records Officer for the U.S. Government, has been researching and writing about emerging technologies and their potential impact on the field of records management. In 2019, NARA issued a white paper on [Blockchain](#), describing how the technology works, how it is being used in the federal government, and the potential implications for records management. Blockchain or distributed ledger technology (DLT) is being utilized for applications such as non-fungible tokens (NFT), cryptocurrency, and smart contracts. This briefing paper focuses on the uses of NFTs and its potential impact on federal records management.

NFTs are digital files that can represent a variety of objects such as images, audio files, videos, or artworks. If agencies create or receive NFTs as they conduct agency business, then the NFTs can be federal records. The definition of a federal record is very broad and includes information stored in digital or electronic form:

[A]ll recorded information, regardless of form or characteristics, made or received by a Federal agency under Federal law or in connection with the transaction of public business and preserved or appropriate for preservation by that agency or its legitimate successor as evidence of the organization, functions, policies, decisions, procedures, operations, or other activities of the United States Government or because of the informational value of data in them (44 U.S. Code § 3301).

Non-Fungible Tokens

A non-fungible token or NFT is a digital item representing a physical or digital asset. NFTs do not have any inherent value, instead NFTs derive value from the assets they represent. NFTs are non-fungible which means they are unique and not interchangeable. In contrast, money is fungible because it is interchangeable with other forms of currency including cryptocurrency or gold. Fungible tokens or cryptocurrencies can be used to make payments and purchase goods or services. Figure 1 illustrates the differences between fungible and non-fungible assets. The following image shows the difference between fungible and non-fungible assets. Gold is an example of a tangible asset that is fungible. Bitcoin is also fungible but not tangible. Artwork or real estate is tangible but not fungible (a Van Gogh is not the same as a Monet). NFTs like crypto kitties are not tangible and non-fungible because each crypto kitty is unique.

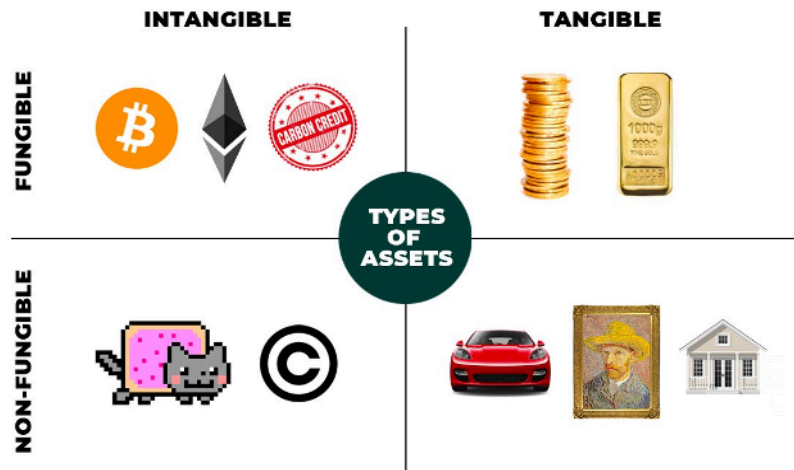


Figure 1. Retrieved from <http://jingculturecrypto.com/wp-content/uploads/2021/03/nft-assets-1024x614.jpg>

Blockchain Basics

NFTs are created using blockchain technology. Before discussing NFT technology, we thought it would be useful to give a very brief introduction on blockchain. For a more in-depth description, we suggest reviewing our [2019 Blockchain white paper](#).

Blockchain or distributed ledger technology (DLT) is a database that is consensually shared, replicated, and synchronized. Unlike traditional databases, DLTs are not used for general data storage, but hold information about transactions. The block is a list of recorded transactions; the chain is transactions recorded with a hash that chains or links, preceding blocks with new blocks. A hash is an algorithm that takes a variable string of data and generates a fixed length value. The network consists of nodes, each containing all transactions within the ledger. DLTs may contain the transactions themselves or may include proof a transaction is valid. Figure 2 illustrates a simplified blockchain.

With blockchain technology, each page in a ledger of transactions forms a block. That block has an impact on the next block or page through cryptographic hashing. In other words, when a block is completed, it creates a unique secure code, which ties into the next page or block, creating a chain of blocks, or blockchain.

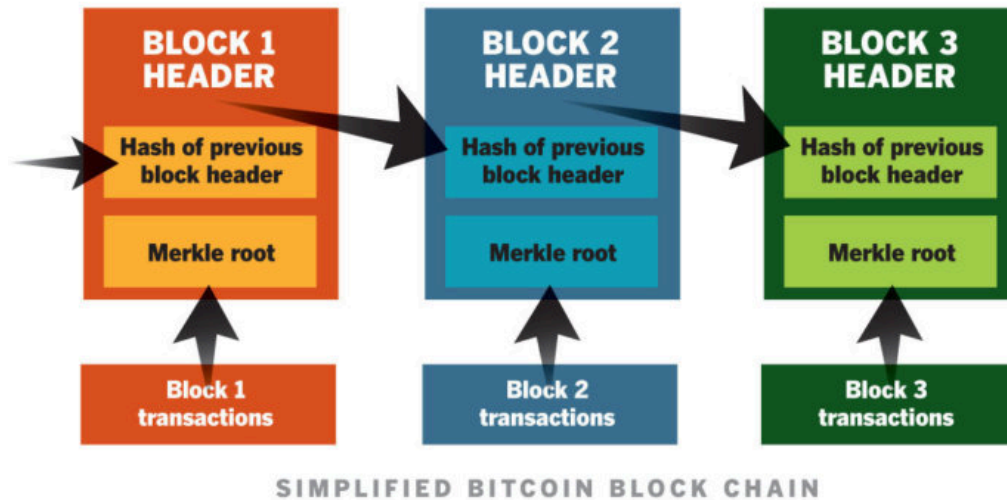


Figure 2. Pursel, Bart. (2018, January 28). Blockchain is Here to Stay. Retrieved from <http://sites.psu.edu/ist110pursel/2018/01/28/blockchain-is-here-to-stay/>

Smart contracts are contracts that are stored on a DLT system and are autonomously executed by an event. NFTs use smart contracts for creation or transfer of ownership, which makes them similar to cryptocurrencies. Cryptocurrencies are a decentralized digital currency that uses DLT to generate units of currency. Both cryptocurrencies and NFTs are digital assets that use DLTs and smart contracts. The main difference is that cryptocurrencies, like traditional currency are fungible, while NFTs, being unique, are non-fungible

Technology

NFTs rely on a blockchain, an NFT marketplace, and a digital wallet. The process to create NFTs is fairly simple and is depicted in Figure 3.

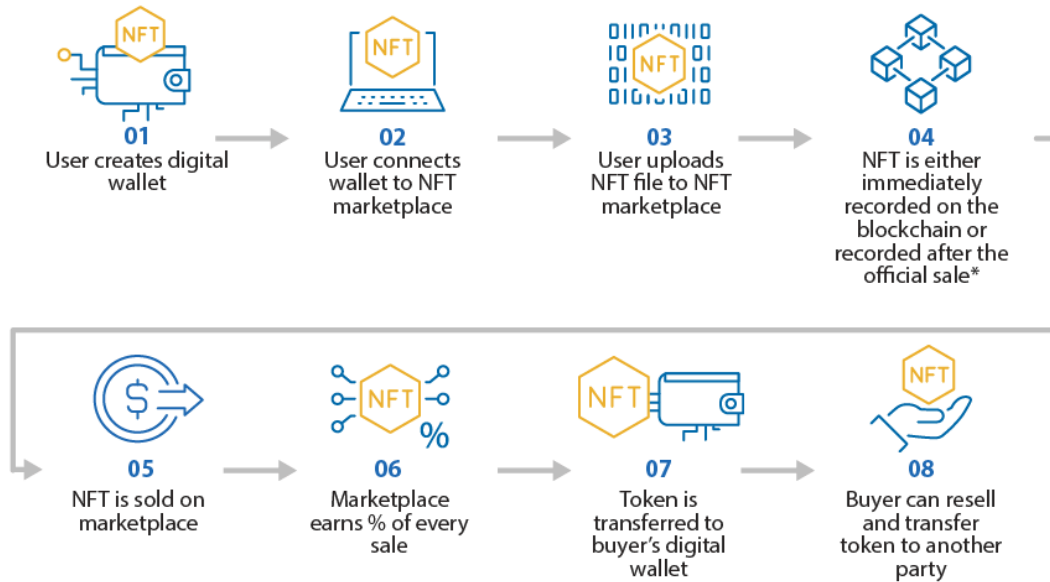


Figure 3. NFT Transaction Process (Busch, 2022.)

An NFT is minted when a creator uploads a digital file to a marketplace. This digital file can be a photo, music, video, game, ticket, or artwork. After the file is uploaded, the marketplace's code executes a unique identifier that is added to the blockchain. The creator or buyer retains the NFT as proof of ownership until it is transferred or destroyed. Digital asset ownership is represented by a code linked to the asset's metadata (Busch, 2022).

NFTs gained popularity in 2017 with a game called CryptoKitties. The game became so popular it nearly shut down the Ethereum blockchain network. In the game players breed and trade virtual kitties. The kitties only exist on the blockchain and only the player who owns them can breed or trade them. These kitties, which are non-fungible tokens, are unique and cannot be divided or shared. Tokens at that time were not designed for use in a game. In response, in 2018 developers created a technical standard, [ERC-721](#), for creating NFTs on the Ethereum blockchain. While the initial purpose of the standard was to represent unique assets in a game, this open source standard provides programmers with the tools to easily create, track, and trade NFTs on Ethereum. While Ethereum¹ is the most commonly used blockchain, other options exist with different networks or marketplaces. The standard implemented an application programming interface (API) which allowed tokens to be transferred among accounts and simplified ownership. (Entriiken, 2018; Banerjee, 2022).

¹ Reference to specific commercial businesses, products, processes, or services by trade name, trademark, manufacturer, or otherwise does not constitute or imply its endorsement, recommendation, or favoring by the United States Government or by the National Archives.

Environmental Impact

The energy consumption of blockchain networks is well known and according to a 2022 report by the Office of Science and Technology Policy (OSTP):

[P]ublished estimates of the total global electricity usage for crypto-assets are between 120 and 240 billion kilowatt-hours per year, a range that exceeds the total annual electricity usage of many individual countries, such as Argentina or Australia. This is equivalent to 0.4% to 0.9% of annual global electricity usage, and is comparable to the annual electricity usage of all conventional (i.e., non-crypto-asset) data centers in the world.

In addition to electricity consumption, the OSTP report notes that usage impacts the environment and human health due to air pollution from burning fossil fuels, water usage and pollution from power plant cooling, solid waste, land degradation, and noise pollution from high-velocity fans.

Changes in the consensus mechanisms used by DLTs may reduce overall energy consumption. Until recently blockchains have relied upon the proof of work (PoW) mechanism that requires large amounts of computing power and electricity to validate transactions. An alternative mechanism for validating transactions is proof of stake (PoS) which consumes less energy. PoS validators are required to put up a stake, or a cache of tokens, to approve transactions and earn a reward. Ethereum, along with several cryptocurrency blockchains, have begun switching to using the PoS consensus mechanism. While PoW has a longer history and is a proven consensus mechanism, benefits of PoS include significantly reduced energy costs, less computational power required, and expansion of network participants.

Use Cases

The most recent applications for NFTs have been in the art world with galleries and major museums selling NFTs either as unique artworks or as numbered digital art representations. Artists creating digital art can use NFTs to provide authentication and certification to the buyer. Museums are exploring NFTs to monetize their holdings and increase their revenue beyond traditional means such as entry and licensing fees, and gift shop sales. Museums already sell images of artworks and a few have sold NFTs as limited editions to raise revenue.

Yet the uncertainty as to what an NFT represents and what is being sold has raised questions. The Uffizi Gallery in Florence, Italy sold an NFT of Michelangelo's Doni Tondo for €240,000 in 2021; however, it was later disclosed that after the fees to the tech company, Cinello, the Uffizi only netted €70,000. In addition to the financial questions, there are also ownership disputes over images of artwork. The Italian ministry that oversees the country's museums has placed a moratorium on contracts with NFT tech providers. Other museums, such as the Hermitage in Russia, the British Museum, and the Museum of Fine Arts in Boston have partnered with tech companies to sell NFTs of their artwork. (Valeonti, 2021; Batycka, 2022).

Traditionally, after an artist sells an artwork to a buyer, the artist does not receive any compensation if the artwork is resold. Future sales benefit the owner of the artwork, not the artist; however, this could change with NFTs. For example, if the bill of sale for artwork is retained on a DLT system, an artist could place a smart contract on the system. In this scenario, artists could provide certificates of authenticity as evidence of provenance to the buyer and execute a smart contract to allow them to receive royalties for future sales. This has the potential to impact the validation of art and the economics of the art world.

There are also discussions that NFTs could be used to streamline government functions such as voter registration or issuing proof of identification like driver's licenses, social security cards, or passports. A recent concept for a soulbound token (SBT) proposes storing personal information in a token that is secure and non-transferable. SBTs are non-transferable NFTs held by a personal, private crypto wallet known as Souls. Ethereum's co-founder Vitalik Buterin based this concept on a gaming feature of soulbound items in World of Warcraft and suggested that such tokens, stored in a digital wallet, could be used for social identities, credentials, memberships, certifications, medical histories, and property rights. Buterin, Eric Glen Weyl, and Puja Ohlhaber, released a white paper in 2022 outlining the SBT concept, detailing potential benefits, and acknowledging that there may be negative implications as well. SBTs are in the early stages of development and are not without controversy, with concerns about privacy, access controls, and malicious uses. (Buterin, 2022; Weyl, 2022.)

Federal Government Framework and Policy

The federal government is considering government-wide policies and regulations for cryptocurrencies and digital assets. In March 2022 President Biden issued [Executive Order 14067 Ensuring Responsible Development of Digital Assets](#). The goals of the executive order include protecting consumers, investors, and businesses; protecting United States and global financial stability and mitigating systemic risk; mitigating the illicit finance and national security risks posed by misuse of digital assets; developing payment innovations and digital assets, promoting access to safe and affordable financial services; and supporting technological advances that promote responsible development and use of digital assets.

A few months after issuing the executive order, the White House released a framework for developing digital assets that tasks several federal agencies with enforcing current regulations on securities and investments and also fostering research and development of digital assets and cryptocurrencies. Additionally, the executive order required the Office of Science and Technology Policy to study the energy and climate implications of digital assets and the report, "[Climate and Energy Implications of Crypto-Assets in the United States](#)", details their findings. In early 2023, the National Science and Technology Council released a report outlining objectives for responsible research and development of digital assets. The objectives for federal research and development should ensure security, privacy, resilience, and sustainability in applications.

Within the government archives and records management fields there might be a role for NFTs to support the certification, authentication, and provenance of records. NFTs may provide a tamper-resistant record of provenance. DLT systems are designed to be immutable, transparent, and provide accountability within specific contexts. Further study is needed to determine if these factors can be used to prove the trustworthiness of federal records. Importantly, while the smart contract or hash for an NFT is part of the DLT system, the asset the NFT represents is not stored on the ledger instead it is stored “off chain” (or off the blockchain). That is, the DLT does not contain actual content of a digital asset (or record). The DLT only stores the NFT’s metadata and a link to the location of the digital asset. This makes it vulnerable to loss since links can be broken (link rot) if the web host is not maintained.

In conclusion, NFTs are exciting; however, it’s important to understand their limitations. NFTs will continue to have challenges when meeting the requirements of records management and evidence. Until additional parts of the record or evidentiary infrastructure are included and addressed, NFTs will likely have limited impact.

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