562F – Tech Driven Transformation

# Non-fungible Tokens (NFTs)

**Campbell R. Harvey** 

Duke University and NBER

### Outline

- Interest
- Definition
- Applications
- Deploying an NFT
- Mechanics
- Use cases
- Risks



NFT Interest

https://www.theblockcrypto.com/data/alternative-crypto-metrics/web-traffic

### NFT Interest



https://www.theblockcrypto.com/data/nft-non-fungible-tokens/marketplaces

### Definition

What is fungibility?

US dollar is a fungible currency

- Any dollar bill has the same value
- Goods can be fungible too. When you buy certain products, you expect it to be identical (bottle of your favorite beer)
- Non-fungible means that each item is unique

### Definition

#### Non-Fungible Token:

- Unique;
- Indivisible; and
- Provably Scarce

#### Similar to other cryptos, NFTs:

- Guarantee the ownership of the asset;
- Are easily transferable; and
- Are fraud proof

# Can be implemented on any blockchain that supports smart contracting

### Protocols

#### ERC-721

- ERC-721 defines the non-fungible standard.
- It is similar to ERC-20 except that each unit has its own unique ID
- Their alternate name, <u>deeds</u>, implies their use case as representing unique ownership of unitary assets; an example could be ownership of a particular P2P loan with its own rates and terms.
- Your private-key is proof-of-ownership of the original
- The content-creator's public key serves as a certificate of authenticity for that particular digital artifact
- Transaction history is visible on the blockchain that NFT is produced on

### Applications

#### Many uses (more detail later)

- Digital Art (GIFs, music, video)
- Fashion
- In-game items
- An essay
- Digital collectibles
- Domain name

EDITORS' PICK | Mar 11, 2021, 10:03am EST | 92,189 views

#### Beeple NFT Sells For \$69.3 Million, Becoming Most-Expensive Ever



Abram Brown Forbes Staff 🕀 Business



**Forbes** 

### Applications

#### Many uses...

- Deed to car, house, mortgage, any financial contract
- Admission ticket
- Lottery ticket
- Tokenize invoices
- Legal documents
- Signatures

## Deploying an NFT

Step-by-step on Ropsten network:

```
SPDX-License-Identifier: MIT
   pragma solidity 0.8.0;
 3
    import "https://github.com/0xcert/ethereum-erc721/src/contracts/token
    import "https://github.com/0xcert/ethereum-erc721/src/contracts/owner
 6
   contract newNFT is NFTokenMetadata, Ownable {
8
     constructor() {
9
        nftName = "Synth NFT";
10
        nftSymbol = "SYN";
11
12
13
14
      function mint(address _to, uint256 _tokenId, string calldata _uri)
15
        super._mint(_to, _tokenId);
        super._setTokenUri(_tokenId, _uri);
16
17
18
```

https://www.quicknode.com/guides/solidity/how-to-create-and-deploy-an-erc-721-nft

### Deploying an NFT

OpenSea makes it easy:



https://testnets.opensea.io/

https://testnets.opensea.io/login?referrer=%2Fasset%2Fcreate

#### Use ERC-721

- NFTs minted through a smart contract that assigns ownership and manages the transfer of the NFT
- After validation by miner, a smart contract is added to a blockchain, e.g., Ethereum

#### **Properties**

- Each token has a unique identifier linked to one Ethereum address
- Each token has an owner and the ownership is easily verifiable
- Can be bought and sold on any Ethereum-based NFT market (because of ERC-721)

#### If you own an NFT, you can easily prove you own it

- Similar to proving you have ETH in your MetaMask account
- Suppose you purchase an NFT and the token is sent to your public address
  - Token proves your copy of the digital file is original
  - Content creator's public key serves as a certificate of authenticity for digital file (the creators public key is a permanent part of token's history and proves you do not have a counterfeit copy)

#### If you own an NFT, you can easily prove you own it

- Alternative way to think of this is signing a message with a digital signature algorithm (DSA)
- When you sign with the DSA, you prove that you have the private key associated with the public address
- A signed message is proof you own the public key without revealing the private key

#### Brief detour on DSA

- Think of a vault that has two keys: public and private.
- Public key available to anyone; but the public key will not open the vault
- Public key is related to (generated from) the private key
- Only the person with the private key can open the vault
- When you open the vault, you prove you have the private key related to that public key

#### If you sell the NFT

- The transaction history is available to anyone and it traces back to the public address of the creator
- It is possible to earn resale royalties

#### Creation of an NFT

- Easy to prove you are the creator
- You can determine the scarcity
- You can determine the resale royalties
- You can sell it on any market (you are not locked into one platform)



What is in the smart contract?

### IPFS powers the Distributed Web

A peer-to-peer hypermedia protocol designed to preserve and grow humanity's knowledge by making the web upgradeable, resilient, and more open.

- If there is a lot of data (large digital file), the data are stored off chain.
- Could be stored in AWS or decentralized storage like IPFS.\*
- Marks items with a "CID" (Content-ID Embedded Images) -Identifies content instead of its repository

\*The InterPlanetary File System is a protocol and peer-to-peer network for storing and sharing data in a distributed file system



#### What is in the smart contract?

### IPFS powers the Distributed Web

A peer-to-peer hypermedia protocol designed to preserve and grow humanity's knowledge by making the web upgradeable, resilient, and more open.

- In IPFS, the URL is determined by a hash of the content
- Any change in the content will lead to a different link

#### Scarcity

- Creator decides
- Tickets to an event might be 2,000 replicas; a piece of art might have a limited number of copies
- In the ticketing example, a particular seat would mean that each of the 2,000 tokens is different.

#### Royalties

- Royalty is a choice a programing choice
- Some NFTs automatically payout royalties to the creator every time there is a transaction.

### Taking out some of the middle

#### Creator economy

- Creators need not handover ownership of content to a platform
- When content is sold (or resold), funds go to the creator.

### More applications

#### Two main areas of growth are art and gaming

• However, NFTs are a diverse space



#### Two main areas of growth are art and gaming

- NFTs provide a record of ownership for in-game objects
- In the past, you could buy items in a game but now you can do that and easily sell the items in the game; selling is one method to "earn" in gaming
- Developers who offer the NFTs can get royalties
- Decentraland you can buy land and they are NFTs



https://www.theblockcrypto.com/data/nft-non-fungible-tokens/nft-overview



https://www.theblockcrypto.com/data/nft-non-fungible-tokens/gaming



https://www.theblockcrypto.com/data/nft-non-fungible-tokens/gaming

#### Axie Infinity gameplay and marketplace



🚬		Login
Recently listed	Recently sold	
👹 Axies 🧼 Land 👹 Items 🎁 Bundles	🕁 Axies 🧼 Land 蜝 Items 🎁 Bundles	
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••• #737551         ••• #7           ••• •• ••• ••• ••• ••• ••• •••	BUYER     SELLER     E 0.017       Dusk Scholarship #1     Lunacian #2608140     \$40.78       (0xa74sa7a71)     (0x9425e1dba)     a minute ago	>
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<u>https://www.coindesk.com/business/2021/10/14/15-nft-use-cases-that-could-go-mainstream/</u> https://www.coinbase.com/learn/crypto-basics/what-is-axie-infinity

#### Many fashion applications:

 Brands such as Dolce & Gabbana are diving into the space and selling millions of dollars worth of digital pieces. Gucci is launching their first NFT collection next month.

The New York Times

### Dolce & Gabbana Just Set a \$6 Million Record for Fashion NFTs

It auctioned a nine-piece virtual/physical collection.



The Gold Glass Dress NFT designed by Dolce & Gabbana and constructed by UNXD, a digital marketplace. UNXD and Dolce & Gabbana

https://www.nytimes.com/2021/10/04/style/dolce-gabbana-nft.html

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#### <u>Auroboros</u>

- London Fashion Week: "the first fashion house to merge science and technology with physical couture."
- Unveiled a line of digital apparel that you "wear" using augmented reality (AR).



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#### <u>Auroboros</u>

- London Fashion Week: "the first fashion house to merge science and technology with physical couture."
- Unveiled a line of digital apparel that you "wear" using augmented reality (AR).
- All NFTs





#### Instead of a paper ticket or the usual electronic

- Ticket can have some art on it
- Concert memorabilia (could be valuable in future)
- Can use the NFT to get discounts on gear
- Revenue goes to artist, crew, venue not the middle people
- Potentially you could be an equity holder in the concert if it goes well you could have a share of the profit!
- You are connected with the artist rather than the middle person

### Community platforms

These are in early stage

- Not practical to use fashion NFTs in Decentraland
- However, in the future, you can imagine the creators wanting to promote a community

### Metaverse

#### Play-to-Earn Is Already the Biggest Star in the Metaverse

With The Sandbox launching in "public alpha" later this month, blockchain-enabled metaverses are going mainstream. Will they be open systems or closed like Facebook?

It is safe to predict

NFTs crucial to the success of the metaverse



#### Sandbox Property can be purchased with native token SAND. Adidas has purchased land in the Sandbox



https://www.coindesk.com/business/2021/10/14/15-nft-use-cases-that-could-go-mainstream/ https://venturebeat.com/2021/12/15/adidas-originals-launches-nft-drop-and-buys-a-plot-in-the-sandbox-metaverse/ https://time.com/6140467/metaverse-real-estate/

### Domains

Domain names such as .com, .edu are centrally managed by <u>DNS</u> and <u>ICANN</u>.

- There is a decentralized domain name service .ETH
- You register with Ethereum Name Service (ENS)
- The registration is an NFT
- Claim a name here: <u>https://app.ens.domains/</u>

Domains

### Here is Ethereum.eth

**\$ENS Now Available for Claiming**  $\langle \rangle$ Claim your \$ENS and participate in ENS governance. ethereum.eth Details eth PARENT 0x0ABa55c93cF7292f71067B0Ba0D8b464592 🗅 REGISTRANT 0x809FA673fe2ab515FaA168259cB14E2BeDe 🗅 CONTROLLER æ 2030.05.04 at 06:12 (UTC-04:00) 📛 Remind Me Extend **EXPIRATION DATE** 0x4976fb03C32e5B8cfe2b6cCB31c09Ba78EB 🗅 RESOLVER RECORDS ADDRESSES 0xde0B295669a9FD93d5F28D9Ec85E40f4cb697BAe 🗋 ETH



#### **Budweiser Twitter Account**



https://www.coindesk.com/business/2021/10/14/15-nft-use-cases-that-could-go-mainstream/ https://fortune.com/2021/10/29/nfts-music-industry/ https://techcrunch.com/2021/11/22/nft-music-rights-startup-royal-banks-55m-investment-from-a16z-crypto/

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### Domains

#### Uses

- ENS can receive cryptocurrency
- Domain is an NFT and can be traded in an NFT marketplace

### Proof of Attendance

#### You show up to class

- You are issued a proof of attendance NFT
- At the end of the course, you sign over your attendance record to the instructor. There is a unique record for each student for each class.
- "Logger" implemented in 697 two years ago by Joey Santoro

### Social media

#### Many applications

 Most interesting to me is reputation. Users can earn tokens or NFTs for proving you have certain skills. See <u>https://rabbithole.gg/</u>





#### It is very difficult for an artist to monetize their content

- Songs could be NFTed. Users would be able to buy into a pool of NFTs so that they could stream from the pool
- This takes out the middle person

### Music

RECENT DRO

#### Royal.io Marketplace

#### Many other entrants





#### **ARTISTS SELL.**

Musicians use royal to sell royalty ownership in their songs and give collectors access to special perks.

#### COLLECTORS BUY.

Collectors can buy royalty ownership in songs directly from their favorite artists in the form of tokens.

BOTH RISE.

Collectors can claim royalties for the music they own after they've accrued. When artists grow, everyone wins.



https://fortune.com/2021/10/29/nfts-music-industry/ Campbell R. Harvey https://techcrunch.com/2021/11/22/nft-music-rights-startup-royal-banks-55m-investment-from-a16z-crypto/

EDITI

#### How it works

Artists and fans co-own music together.



#### Loans in DeFi right now are backed by ERC-20 tokens

- Some of the DeFi tokens are backed by virtual assets
- Certain tokens have physical backing like USDC
- However, there is a vast amount of physical value that is not tokenized
- In the future, NFTs that tokenize that physical value will be used as collateral



#### Loans in DeFi right now are backed by ERC-20 tokens

- However, NFT collateral is not without complication
- It is easy to continuously check the value of collateral of, say, ETH
- It is not so straightforward to monitor the collateral value of an NFT that might represent an illiquid asset
- To use the last traded price could be very misleading



#### Loans in DeFi right now are backed by ERC-20 tokens

- Possible solution is for the borrower to offer a set of NFTs as collateral and the lender gets to choose the NFTs
- The chosen NFTs go into an escrow
- If there is default, the escrow goes to the lender

DeFi

nftfi

The marketplace for NFT collateralised loans

Put your NFT assets up as collateral for a loan, or offer loans to other users on their non-fungible tokens.





#### Self-sovereign identity (SSID)

- You own your identity and all your data
- Currently Facebook/Meta or Google use your data (and you do not generally get compensated for that)
- No more usernames or passwords
- Secure messaging
- DeSo

## Splitting NFTs

#### NFTs cannot be split but fractional ownership is possible

- Vault the NFT in a smart contract and then issue ERC-20 tokens.
- There ERC-20 tokens representing ownership of the NFT could be traded anywhere
- Fractionalization allows for the possibility of owning a small share of an asset that is outside your budget (like a multimillion dollar painting)
- Allows for new possibilities in terms of portfolio diversification

### Splitting NFTs

#### ERC-1155

- ERC-20 and ERC-721 tokens require an individual contract and address deployed to the blockchain.
- These requirements can be cumbersome for systems that have many tokens, which are closely related, possibly even a mix of fungible and nonfungible token types.

### Splitting NFTs

#### ERC-1155

- ERC-20 and ERC-721 tokens require an individual contract and address deployed to the blockchain.
- These requirements can be cumbersome for systems that have many tokens, which are closely related, possibly even a mix of fungible and nonfungible token types.
- ERC-1155 resolves this complexity by defining a <u>multi-token model</u> in which the contract holds balances for a variable number of tokens, which can be fungible or nonfungible.

### NFT security

#### A strong blockchain like Ethereum is immutable

- Transaction history is transparent thereby making it easy to prove ownership
- Strength of blockchain makes it unlikely the NFT can be "stolen"
- Trading of NFT can happen on decentralized exchanges with small transactions costs
- Markets are available 24-7



1. Why is this valuable given it is simple to make a digital copy?

- It is one thing to make a copy another to own it.
- NFTs allow you to own something even though, say, the image may be widely shared
- Indeed, the more people share the image, the more valuable the image is
- Owning the content is always more valuable than not owning

NFT risks

- 2. Gas fees can be more than the value
- This is true on Ethereum chain (currently) but not on other chains

CONTRAC \$0.0	CT INTERACTION	
DETAILS	DATA	
GAS FEE		EDIT <b>\$136.54</b> ♦0.364715
		AMOUNT + GAS FEE



3. You could potentially sell the same thing on two different blockchains

- This is unlikely to work given all the blockchains are open and you can easily check to see if it was sold before
- In the future, there will be cross-chain technology to make this even more unlikely



#### 4. What are legal options in enforcing rights?

- No case law on NFTs
- Complicated because they are global

### NFT risks

#### 5. NFTs represent larger digital files are stored off chain

- Introduces a point of failure (website disappears)
- As data storage cost decreases (currently \$0.01 per gb), it is likely that many off-chain files will move on-chain. However, even this is unlikely for large files like video files.



#### 6. Current ERC-721 implementation

• ERC-721 includes an optional functionality to change the URL where the content resides.



### Risks



#### 6. Moxie Marlinspike NFT Project

- Moxie noticed that many of the NFTs posted on major marketplaces, like OpenSea, just points to a VPS running on Apache Software
- Essentially, most of the NFTs are being hosted on a central location
- Anyone with access to that machine, anyone who buys that domain name in the future, or anyone who compromises that machine can change the image, title, description, etc., for the NFT to whatever they'd like at any time (regardless of whether or not they "own" the token).



- As an experiment, Moxie created an NFT that changes based on who is looking at it
  - The web server that connects with the image can choose to serve different images based on the IP of the requestor
  - The NFT looked one way on OpenSea, another way on Rarible, but when bought and viewed in the crypto user's wallet, it displayed something completely different
  - Moxie emphasizes the fact that many high profile NFT projects can turn into other images or be hacked to display other images because of the NFT specifications.





NFT on OpenSea

OpenSea

https://moxie.org/2022/01/07/web3-first-impressions.html





NFT on OpenSea

OpenSea



Same NFT on Rarible



https://moxie.org/2022/01/07/web3-first-impressions.html





NFT on OpenSea

OpenSea



Same NFT on Rarible

Rarible



Same NFT in a wallet

Wallet

https://moxie.org/2022/01/07/web3-first-impressions.html

7. Centralized players (Aggregation Theory) in the NFT Market

- OpenSea controls the demand of the NFT market, and they have recently banned collections from their platform
  - While the collections can still be traded since they exist on the blockchain the lack of trading on OpenSea diminishes the demand and trading volume for the NFT project
  - OpenSea was the first NFT marketplace, and it is still the dominant marketplace it surpassed \$14 billion in trading volume in 2021 alone

https://stratechery.com/2022/opensea-raises-money-bans-nfts-openseas-value-cryptos-aggregators/

### Risks

#### **OpenSea Market Dominance**



https://stratechery.com/2022/opensea-raises-money-bans-nfts-openseas-value-cryptos-aggregators/ https://www.statista.com/statistics/1274843/nft-marketplaces-with-highest-volume/

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### **Alternative Protocols**

- ERC-2309
- Makes the minting of NFTs a lot more efficient

### Conclusions

#### Dramatic growth in NFTs

- However, most of the interest is in gaming and art
- Very large number of alternative uses that are relatively unexplored