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CSE 1006
Blockchain and Cryptocurrency Technologies

Digital Assignment 1

Case Study on Blockchain in Non-Fungible Tokens (NFTs)

Submitted By:

Ishan Bharadwaj (19BCI0194)
Abeer Aftab (19BCI0197)

Submitted To:

Dr. Govinda K
(Associate Professor Grade 2,
SCOPE)

Blockchain in Non-Fungible Tokens

1. Aim

A case study on digital assets that run on blockchain, called Non-Fungible Tokens or NFTs

2. Abstract

A fungible item or an asset in economics is something with units which can be interchanged like currency. For example we have five ten-rupee notes in your wallet, we may not want to carry around so much change so you exchange them for a single fifty-rupee note. The value of your money is still fifty rupee regardless of the fact it's now in a different form.

Non-fungible assets or tokens (NFTs) are the opposite. Each one is unique and has unique properties, and can't be easily substituted for something similar. These assets can be anything ranging from digital art to paintings or even houses. For example we can take a photo of the painting or buy a print but there will only ever be the one original painting. **NFTs are unique assets** in the digital world that can be bought and sold like any other piece of property, but they have no tangible form of their own. The digital tokens can be said to be like certificates of ownership for physical or virtual assets.

Non-fungible tokens or NFTs are digital assets that run on blockchain. The value of NFTs largely stems from the idea of scarcity. Collectors of NFTs can own unique digital assets like art, sports highlights, or songs which can be bought and sold on marketplaces. NFTs in part contain similar characteristics to traditional tangible collectible items, but NFTs have unlocked business possibilities that are far-reaching.

A NFT take care of these properties through **the blockchain where the information is recorded**. NFTs are cryptocurrencies but unlike fungible cryptocurrencies like bitcoin, they are completely unique. They exist as a string of characters (numbers and letters) stored on a **blockchain ledger**. This information contains who owns the digital asset, who sold it, and the timestamp of when it was sold. This information

is also **encrypted using hash functions**, ensuring the NFT's authenticity and scarcity. In doing so, they fix a difficult problem for digital creators on the internet on how to make their creation unique and more valuable. So, with NFTs, the creators end up having the scarcity because they are non-fungible and because of that, there's only one of these tokens that can exist. It can't be traded for anything similar because it is unique, and they wind up getting that scarcity and that limitation which helps drive up some of the prices. With NFTs, an asset such as artwork can be **"tokenized"** to create a digital certificate of ownership that can be bought and sold.

Blockchains like Ethereum, Flow, and Tezos have their own standards when it comes to supporting NFTs but each works to ensure that the digital item represented is authentically one-of-a-kind. NFTs are now being used to commodify digital assets in art, music, sports, and other popular entertainment.

Ethereum blockchain supports and is the basis for most of the currently offered NFTs because it has the **ERC-721 token standard**, enabling NFT creators to capture information which is relevant to the digital artifacts possessed by them and store it in the form of tokens on the blockchain.

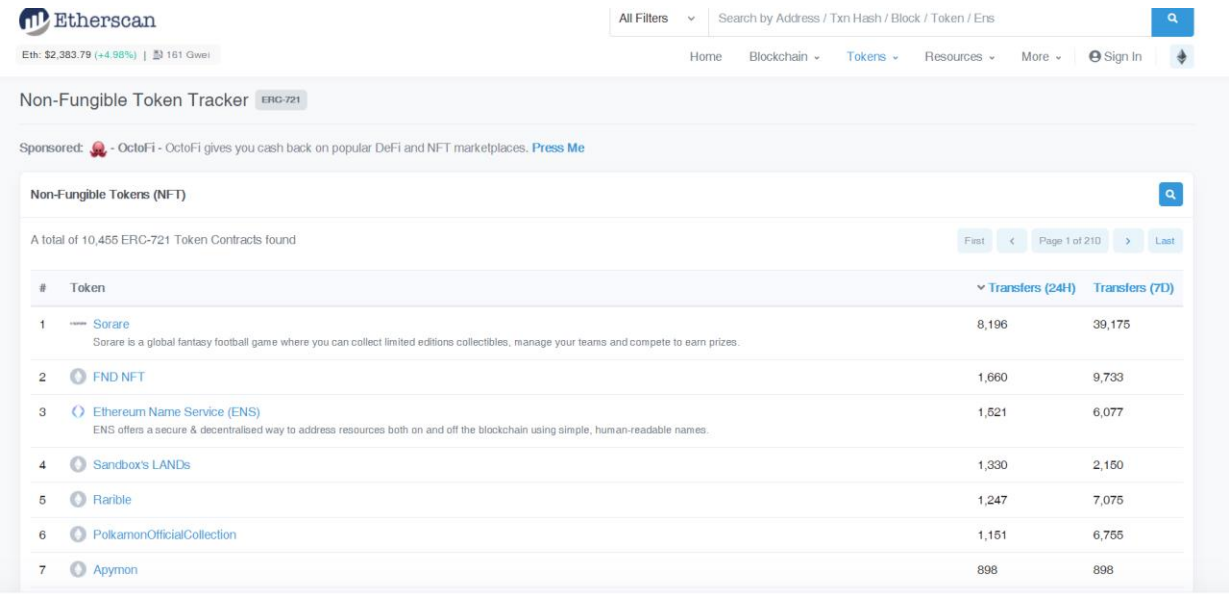
The ERC-721 token standard

The ERC-721 (Ethereum Request for Comments 721) was proposed by William Entriken, Dieter Shirley, Jacob Evans and Nastassia Sachs in 2018 and it is a Non-Fungible Token Standard that implements an API (Application Program Interface) for tokens within **Smart Contracts.**
It provides functionalities like:

- Transferring of tokens from one account to another
- Getting the current token balance of an account
- Getting the information of the owner of a specific token and also the total supply of the token available on the network

There are some other functionalities as well like to approve that an amount of token from an account can be moved or transferred by a third party account.

If a Smart Contract implements these methods and events, it can be called an ERC-721 Non-Fungible Token Contract and, once deployed, it will be responsible to keep track of the created tokens on Ethereum.



https://etherscan.io/tokens-nft by Etherscan is an NFT tracker

3. Introduction

An NFT is a distinctive unit created on a blockchain to represent a digital asset, that ensures positive possession to buyers. Technically, anyone will flip any digital file into an NFT and sell them on AN NFT market. The attractiveness is that whereas the digital file will be duplicated, the NFT of that file cannot.

NFT Standard:

On Ethereum, the ERC-721 standard defines nonfungibility. This standard is comparable to ERC-20, ordinarily employed in and the most used standard in Ethereum, except every unit has its own distinctive ID, instead of all units being keep as a single balance. This distinctive ID can be linked to extra metadata that differentiate the token from others' stemming from the same contract. under the balanceOf(address) method, the entire range of nonfungible tokens (NFTs) within the given contract that the address owns is returned. an additional method,

ownerOf(id), returns a particular token, referenced by its ID, that the address owns. Another important distinction is that ERC-20 permits for the partial approval of an operator's token balances, whereas ERC-721 uses an all-or-nothing approach. an operator approved to use the NFTs can move any of them.

3.1 Origin of NFTs

The technology for NFTs was discovered around in 2010 but gain popularity in 2017 with CryptoKitties that allowed userse to buy digital cats with cryptocurrency.

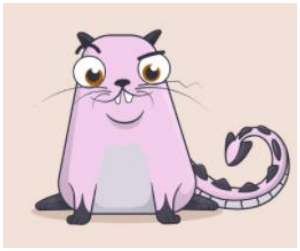
A historical example of Crypto based tokens like NFTs was Color Coins, founded in 2012 and were using Bitcoin blockchain. They were basically denominations of Bitcoin only and were used to represent various assets like: property, issue shares of a company, coupons, colllections etc. They were like NFT's and can be used as certificates of ownerships but this implementation failed as bitcoin blockchain didn't had necessary standards to support them.

The creation of ColorCoins made people think about the strength of issuing tokens of ownership to digital assets so as to make them authentic.

In 2014 a financial platform Counterparty was founded which used bitcoin blockchain and the platform was used for trading card games. The platform had various assets for trading card games which were like NFTs.

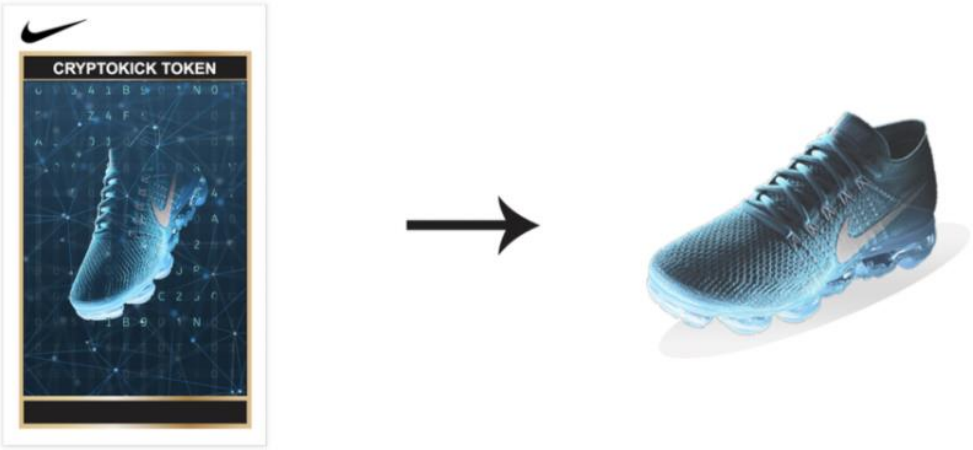
In 2017 Ethereum gain fame and an American studio Larva Labs released CryptoPunks. It was a website used to trade unique characters which were cartoons on Ethereum blockchain. In the same year another project called CryptoKitties was released which was a game where players traded and adopted virtual digital cats. This game went viral and raised an investment of $12.5 million with some assets (cats) were selling for over $100,000.

CryptoPunks
(Cryptopunk #3100 and Cryptopunk #7804
were sold for $7.6 million each



Meet Dragon, a CryptoKittie.
She's worth $170,000 as of today.

CryptoKitties lead to the rise of NFTs and with time people got to understand the potential in NFTs and started making projects using ERC721 standard on Ethereum, this lead to a potential growth of NFTs like in 2019, the shoe company Nike patented a system called CryptoKicks using NFTs to verify the authenticity of sneakers and provide a virtual version of the shoe.



3.2 Need of NFTs

Today, the bulk of tokens that exist on blockchains are fungible — every unit is interchangeable with another unit (cryptocurrency or dollars) but, further as extra real-world property is tokenized, a growing percentage of tokens on blockchain networks may be non-fungible.

Representing unique things seems to be an essential capability for blockchains due to the fact maximum of the world's belongings are unique. Your automobile has a completely unique chassis number, your ID proof or software license has a

completely unique serial number. As more enterprises try to get into blockchain technology, NFTs play a major role in ushering in a new era of the digital economy.

Any digital asset can be easily copied or reproduced but with NFTs one can still prove that he is the rightful owner of the original asset or token because now it gets recorded on the blockchain, and now the owner can sell or auction the asset to someone else easily with authenticity.

Supply Chain Management: NFTs are needed basically everywhere in supply chain management. With blockchain technology evolving, the supply chains are now using it. Some organizations have problems in maintaining the chain because their products get reproduced resulting in loss. To tackle this NFTs can be used. Some organizations even now sell bottles of wine, vaccines and pharmaceuticals by first tokenizing them and these are tracked on blockchains for fraud detection.

Software licensing: It is one more arena where NFTs can be used. Software licenses ware mostly represented by keys which are some usually unique strings of letters and numbers. The ones who have the key can only access the software program and the key served as verification that you were an authenticated user. NFTs can be held in wallets on browsers or mobile devices and can serve as the key for the users to access the software. Here, the tokens will be nontransferable and can only be used within licensing period.

Real estate industry: This industry also deals with unique assets, where no two assets can be the same. Even after good regulations and laws which are used in the ownership of the land, the ownership can eventually be used as NFTs. This will reduce property frauds and land mafia.

Identity management: It is another sector for organizations to use NFTs in. Occupation specific credentials of an organization for a person like medical licenses, student degrees and other certificates are unique for every individual and can be issued, tracked and maintained as NFTs on blockchain network.

Executing agreements: NFTs can revolutionize the methods of executing agreements for exchange of money, shares and property through smart contracts. These digital contracts can be used to get rid of a third party arbitrator like courts and a computer program on blockchain shall be used to confirm the conditions of agreements.

3.3 Sources

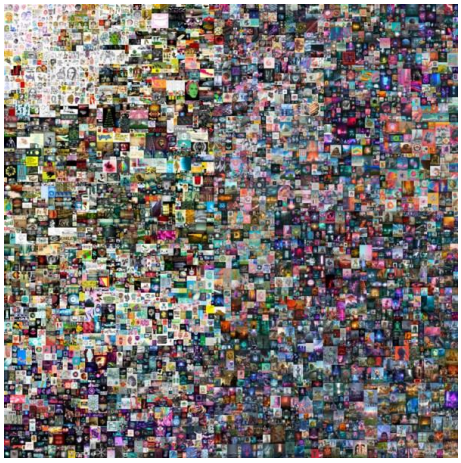
NFTs have revolutionized digital communications and due to their inherent characteristics as they are easily transferable and how they help in maintaining ownership rights in decentralized applications, they have a very wide and interesting set of use cases.

Some of the big industries adopting and implementing NFTs are discussed below.

Decentralized Finance (DeFi)

NFTs have interesting applications in DeFi. Their alternate name, deeds, implies their use case as representing unique ownership of unitary assets; an example can be ownership of a selected P2P loan with its own rates and terms. The asset could then be transferred and sold via the ERC721 interface. Another use case may well be to represent a share in an exceedingly lottery. Lottery tickets may be considered nonfungible because just one or a limited number are winning tickets and therefore the remainder are worthless. NFTs even have a powerful use case in their ability to bridge financial and nonfinancial use cases via collectibles. NFTs may represent scarce items during a game or other network and retain quantity in secondary markets for NFTs.

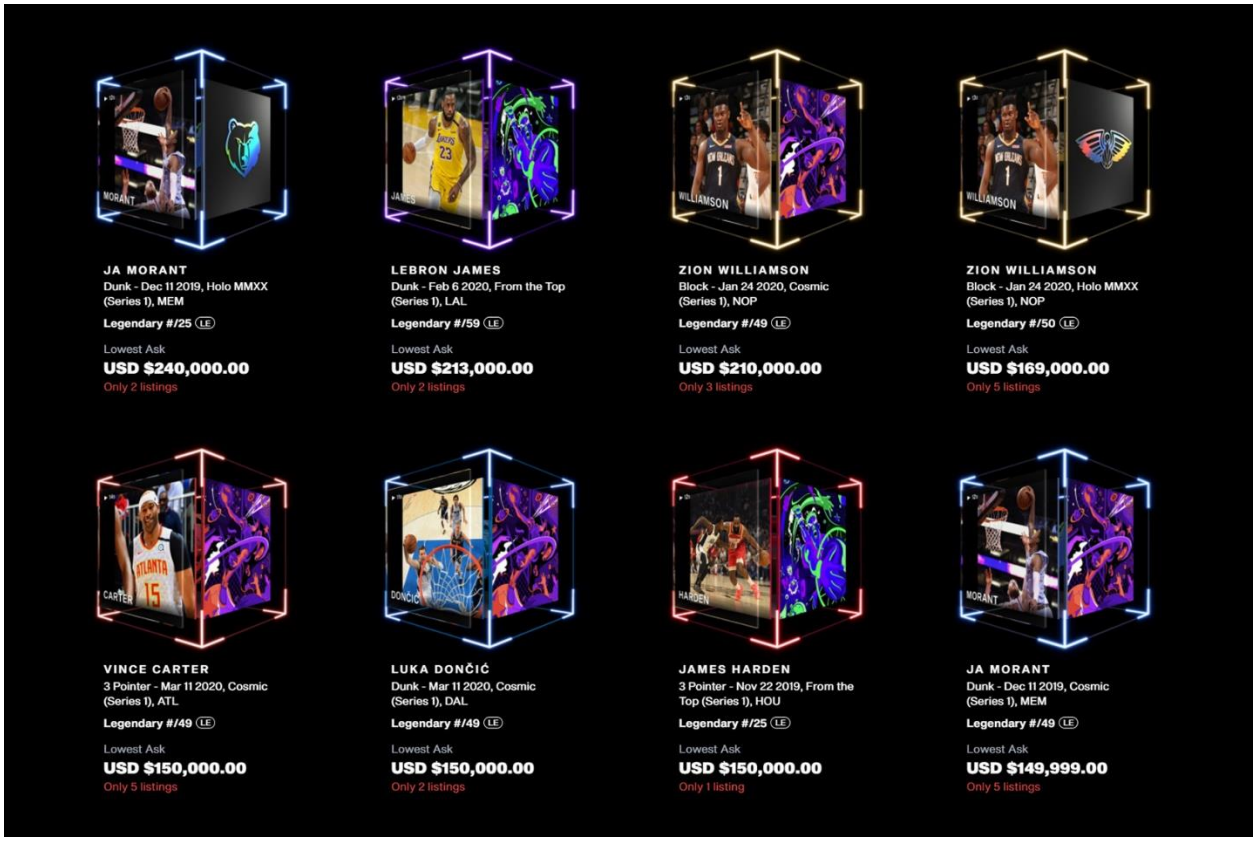
Digital Art



Everydays: the First 5000 Days

Everydays: the First 5000 Days is a digital work of art by Mike Winkelmann. The work is a collage of 5000 digital images. An NFT representing it was sold for $69.3 million March 11, 2021, the highest price paid for an NFT and the third-most expensive work by a living artist.

Sports



These are some of the most celebrated moments in the history of basketball recreated as NFTS in video formats and sold for as high as $240,000.00.

Also Belgium's leading football league, the Jupiler Pro League partnered with gaming company Ubisoft's Strategic Innovation Lab and startup Sorare to launch a fantasy football game having digital collectibles as NFTs.

Social Media

Jack Dorsey, Twitter's founder auctioned his first tweet as an NFT. The tweet was bought using ether cryptocurrency at $2.9 million.

Music Industry

Steve Aoki and Antoni Tudisco, *hairy*
$888,888.88, March 2021, Nifty Gateway

Steve Aoki released a limited art collection in March 2021 via an NFT sale. The event brought in $4.25 million. The sale was led by an auction price of $888,888.88.

Virtual Property.

Virtual land on the blockchain gaming platform Axie Infinity, named “Genesis” Estate, was sold for $1.5 million.

4. Literature Review

[1] D. Chirtoaca, J. Ellul and G. Azzopardi, "A Framework for Creating Deployable Smart Contracts for Non-fungible Tokens on the Ethereum Blockchain," 2020 IEEE International Conference on Decentralized Applications and Infrastructures (DAPPS), 2020, pp. 100-105, doi: 10.1109/DAPPS49028.2020.00012.

This research paper proposes a framework that provides developers with a smart contract suite that offers complete implementations of the ERC721 standard and common extensions and features frequently encountered in ERC721-based applications.

[2] S. Goyal, K. Sanjith, A. Sisodia, N. M. Suhaas and S. Akram, "Transactions Process in Advanced Applications on Ethereum Blockchain Network," 2020 International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT), 2020, pp. 275-281, doi: 10.1109/RTEICT49044.2020.9315682.

This research paper helped us to find out how exactly transactions are performed on the ehtereum blockchain network.

[3] Chevet, Sylve, Blockchain Technology and Non-Fungible Tokens: Reshaping Value Chains in Creative Industries (May 10, 2018). Available at SSRN: https://ssrn.com/abstract=3212662 or http://dx.doi.org/10.2139/ssrn.3212662

This paper offers an analysis of cryptocurrencies and blockchain's technical underpinnings, specifically of Non-Fungible tokens and cryptocollectibles, and the changes these innovations can bring about in the art market.

[4] NFTs in Practice – Non-F actice – Non-Fungible Tokens as Core Component of Blockchain-based Event Ticketing Application Ferdinand Regner University of Augsburg, regner.f@gmail.com Nils Urbach University of Bayreuth, nils.urbach@uni-bayreuth.de André Schweizer University of Bayreuth, andre.schweizer@fim-rc.de

This research paper implements a simple blockchain based event ticketing system helping us to understand the applications of NFTs in real world.

[5] Chohan, Usman W., Non-Fungible Tokens: Blockchains, Scarcity, and Value (March 24, 2021). Critical Blockchain Research Initiative (CBRI) Working Papers, 2021.
https://ssrn.com/abstract=3822743 or http://dx.doi.org/10.2139/ssrn.3822743

This research paper helped us to understand the value and the scarcity of NFTs and rising investor's attention towards them in the market.

[6] Michael Dowling, Is non-fungible token pricing driven by cryptocurrencies?, Finance Research Letters, 2021, 102097, ISSN 1544-6123, https://doi.org/10.1016/j.frl.2021.102097.

The research paper focuses on the real prices of the tokens used as NFTs on the blockchain network. As their ownership is safe, they have high prices.

[7] Krasny, Ros, "Prices in a 'Bubble,' Beeple Says After His $69 Million NFT Sale",2021 Bloomberg.com; 3/21/2021, pN.PAG-N.PAG, 1p

This article gave us information about how Everydays: the 5000 days was sold at such a huge price only because it was an NFT

[8] Chow, Andrew R. Zorthian, Julia, "NFTs and the Crypto Art Revolution", TIME Magazine. 3/29/2021, Vol. 197 Issue 11/12, p36-43. 8p. 6 Color Photograph

This article gave us an insight over how art theft is common on digital spaces and why there is a need to use NFTs in order to safeguard the authenticity of such art pieces.

[9] H. Watanabe et al., "Enhancing Blockchain Traceability with DAG-Based Tokens," 2019 IEEE International Conference on Blockchain (Blockchain), 2019, pp. 220-227, doi: 10.1109/Blockchain.2019.00036.

This research paper proposes to implement directed acyclic graphs in non-fungible tokens to allow the history of the NFTs effectively explored. It helped us to understand in how many vast ways NFTs can be used.

[10] Software licences as non-fungible tokens by John Griffin Apr 13, 2018 on https://medium.com/atchai/software-licences-as-non-fungible-tokens-1f0635913e41

The article makes us understand the need of NFTs basically in software licensing in order to stop piracy and unauthorized use of software.

[11] Frye, Brian L., NFTs & the Death of Art (April 19, 2021). Available at SSRN: https://ssrn.com/abstract=3829399 or http://dx.doi.org/10.2139/ssrn.3829399

The research paper argues that the market for NFTs is really a market for unique digital files, not a market for artworks. While NFTs are absurd, markets have survived far worse. And perhaps NFTs could liberate art from the art market.

5. Proposed Approach

5.1 Real-world assets

NFT is a promising way to tokenize real-world assets this approach ensures efficiency. Converting a physical asset to a digital asset makes it simple to be processed easily. It eliminates various intermediate problems. NFTs allows both sellers and buyers to connect directly and interact with each other without third party interference on dedicated online markets to choose good deals and use smart contracts for authenticity.

Soon in the future every unique identification or licensing software will use NFTs as they are the safest forms to signify ownership of an asset.

5.2 Implementing a simple NFT project

5.2.1 Proposed Architecture

We aim to implement a simple NFT project which can be used to issue simple color tokens using color codes on a personal Ethereum blockchain. The code includes a smart contract made using solidity on Ethereum blockchain. This contract further uses ERC721 standard for Ethereum. The smart contract basically automates the minting of the color tokens. If the token already exists in the blockchain then it doesn't allow the token to be minted.

The virtual Ethereum blockchain is implemented using ganache. The blockchain has several account addresses available these are virtual and can only be used for development purposes. The account address is then used in the metamask wallet to connect it with virtual account on ganache.

The project is basically a webpage. The user is asked to enter the color code and a color token of the code is minted. When the user clicks on mint button the metamask wallet appears and the user is asked to pay some gas fee using his account address connected to the metamask on ganache. After the transaction is complete the token is issued under the ownership of the user's account address, thus implementing NFT.

Tech Stack used:

Solidity: For making smart contract

Metamask: For Ethereum transactions on a private network

Truffle: For making a virtual private blockchain

Ganache: For making accounts on the private blockchain

Web3: To connect the private blockchain network to the web app

React: To create Frontend for the web app

5.2.2 Implementation

Solidity code for smart contract color.sol used for tokens:

```
pragma solidity 0.5.0;
import "./ERC721Full.sol";
//code for the token
contract Color is ERC721Full {
   string[] public colors;
   mapping(string => bool) _colorExists; //checks color
   constructor() ERC721Full("Color", "COLOR") public{
   }
   function mint(string memory _color) public {
      //Require unique color
      require(!_colorExists[_color]);
      uint _id = colors.push(_color);
      _mint(msg.sender, _id);
      //Color - add it
      //Call mint()
      //Color - track it
      _colorExists[_color] = true;
   }
}
```

Solidity code (migrations.sol) to keep track of migrations on the blockchain network (truffle ganache) used for tokens:

```
pragma solidity >=0.4.21 <0.6.0;
contract Migrations {
  address public owner;
  uint public last_completed_migration;
  constructor() public {
    owner = msg.sender;
  }
  modifier restricted() {
    if (msg.sender == owner) _;
  }
  function setCompleted(uint completed) public restricted {
    last_completed_migration = completed;
  }
  function upgrade(address new_address) public restricted {
    Migrations upgraded = Migrations(new_address);
    upgraded.setCompleted(last_completed_migration);
  }
}
```

Solidity code (color.test.sol) to issue and deploy tokens on the local blockchain:

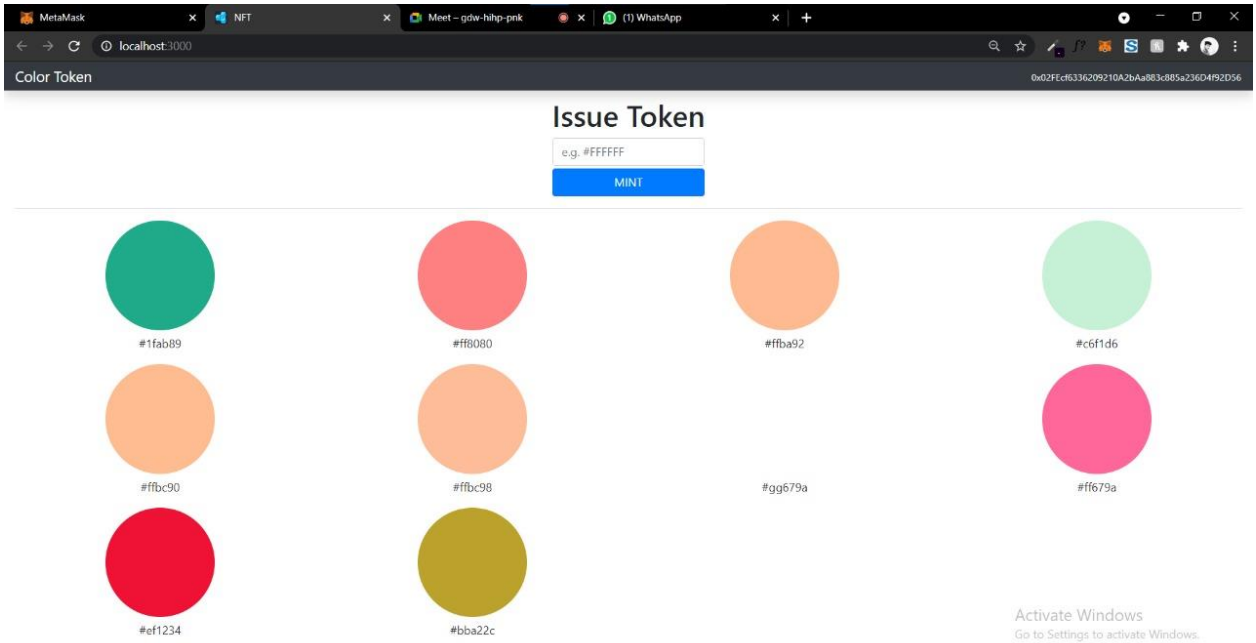
```
const { assert } = require('chai')

const Color = artifacts.require('./Color.sol')

require('chai')
  .use(require('chai-as-promised'))
  .should()

contract('Color', (accounts) => {
  let contract
```

```
before(async () => {
   contract = await Color.deployed()
})

describe('deployment', async () => {
   it('deploys successfully', async () => {
     const address = contract.address
     assert.notEqual(address, 0x0)
     assert.notEqual(address, '')
     assert.notEqual(address, null)
     assert.notEqual(address, undefined)
   })

   it('has a name', async () => {
      const name = await contract.name()
      assert.equal(name, 'Color')
   })

   it('has a symbol', async () => {
      const symbol = await contract.symbol()
      assert.equal(symbol, 'COLOR')
   })
})

describe('minting', async () => {
   it('creates a new token', async () => {
      const result = await contract.mint('#EC058E')
      const totalSupply = await contract.totalSupply()
      //SUCCESS
      assert.equal(totalSupply, 1)
      //console.log(result)
      const event = result.logs[0].args
```

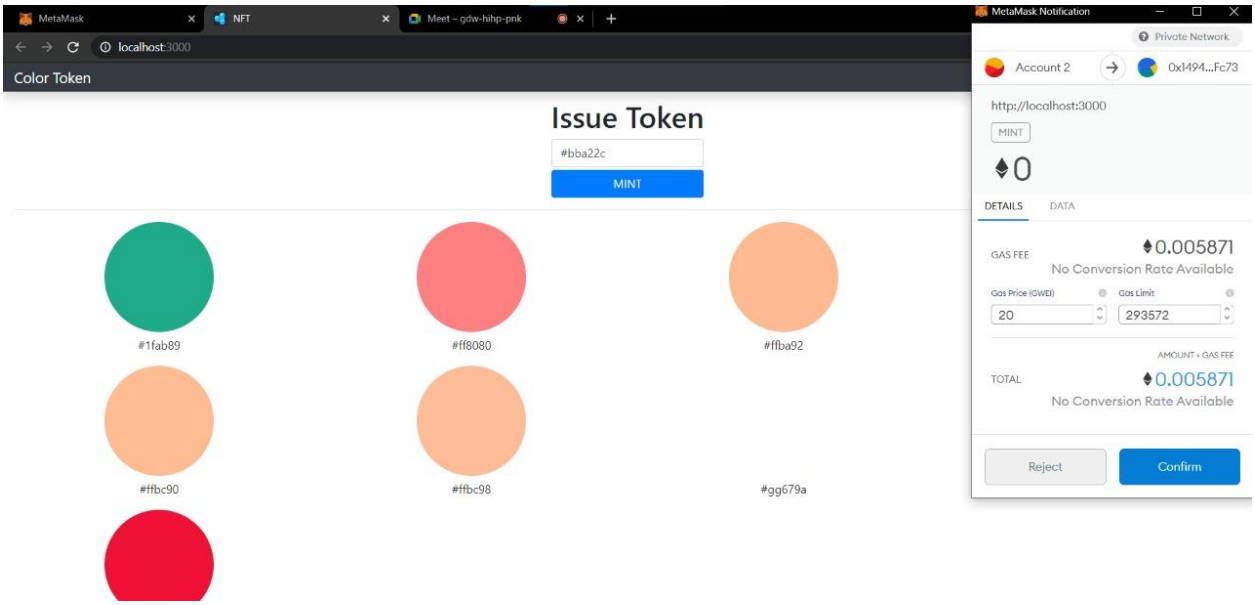
```
        assert.equal(event.tokenId.toNumber(), 1 , 'id is correct')
        assert.equal(event.from,
'0x0000000000000000000000000000000000000000', 'from is correct')
        assert.equal(event.to, accounts[0], 'to is correct')

        //FAILURE: cannot mint same color twice
        await contract.mint('#EC058E').should.be.rejected;

      })
    })

    describe('indexing', async () => {
      it('lists colors', async () => {
        //Mint 3 more tokens
        await contract.mint('#5386E4')
        await contract.mint('#FFFFFF')
        await contract.mint('#000000')
        const totalSupply = await contract.totalSupply()

        let color
        let result = []

        for (var i = 1; i <= totalSupply; i++) {
          color = await contract.colors(i - 1)
          result.push(color)
        }

        let expected = ['#EC058E','#5386E4','#FFFFFF','#000000']
        assert.equal(result.join(','),expected.join(','))
      })
    })
})
```

5.2.3 Results

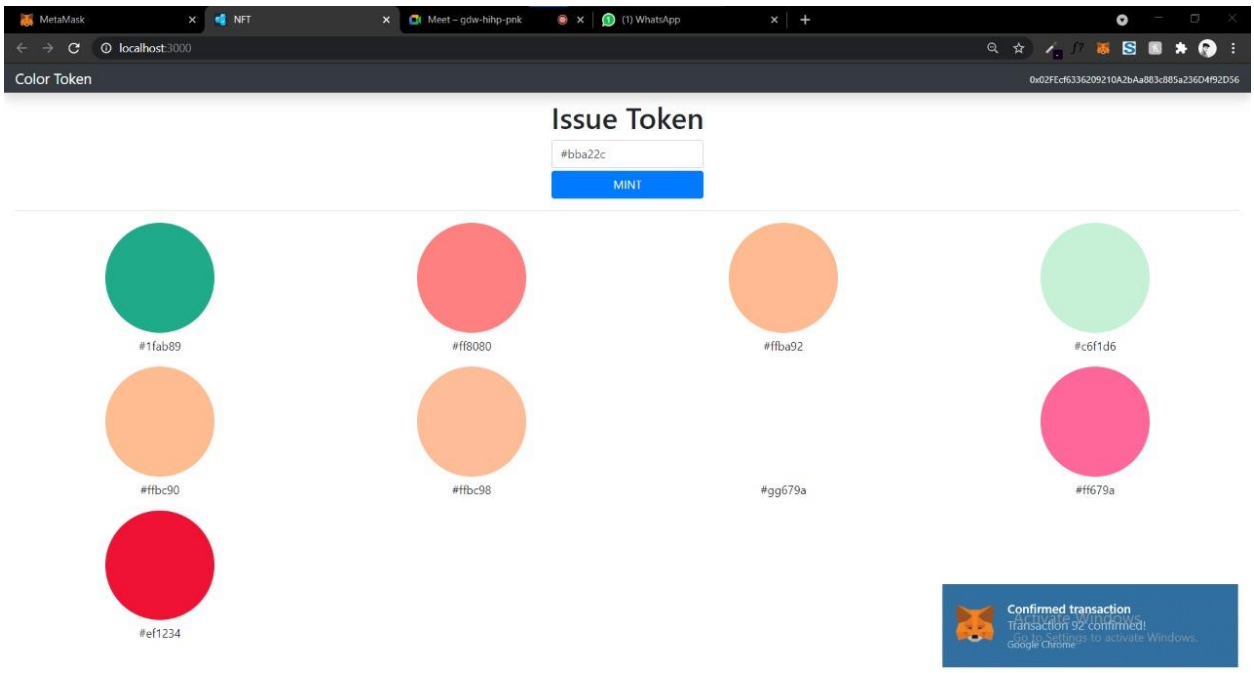
1. The user is asked to enter a color code and mint the token



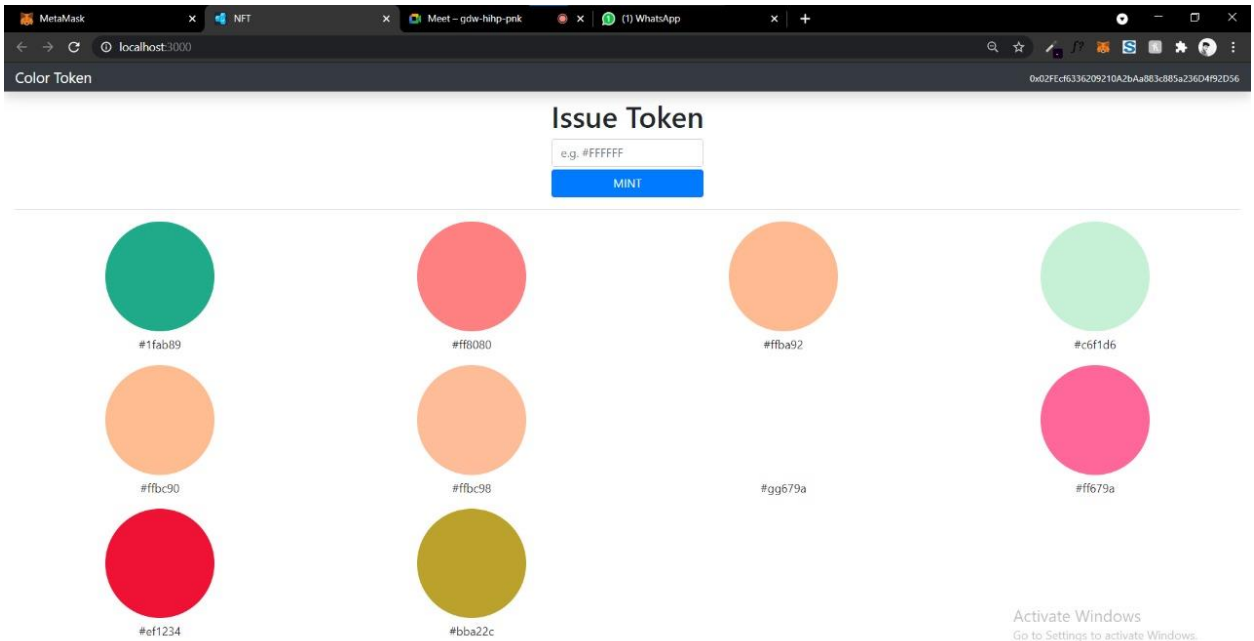
2. The user is then asked to pay the gas fee for issuing the token



3. The transaction is then confirmed by the metamask and the Ethereum balance is reduced in the ganache virtual account



4. The token is issued and is added on the blockchain as well as on the web page



Github URL for the project:
https://github.com/abeeraftab123/Color-Token-Collectible-NFTs

5.2.4 Justification

Such results were only obtained because the project was implemented successfully. The token is successfully made and is issued under the ownership of the account address of the user who minted it. This implementation shows us that using NFTs one can authorize his tokens. If we try to mint another token having the same color code as the ones already on the blockchain, the program won't let it get printed thus ensuring the authenticity and the uniqueness of the token present on the blockchain.

6. Conclusion

We saw what Fungible tokens (e.g., fiat currency) are and how our focus of study, Non-fungible tokens differ from them. A Fungible token can easily be exchanged for any other token of the same type/value. Just like a Dollar bill can be exchanged for another Dollar bill, with no difference to the user while NFTS cannot be exchanged or replaced with other tokens of the same type. If you lend an NFT to someone, you expect them to return the very same token.
Fungible tokens of the same type are identical in specification while each NFT is unique and differs from other tokens of the same class and this makes them impossible to swap.

As technology is evolving more and more people are moving towards buying and selling their assets digitally, due to which the number of digital scams and frauds related to such assets are increasing day by day. NFTs are the need of the hour for many industries worldwide and as the blockchain technology evolves, so do more people would come to know about this latest piece of technology as it reduces frauds and scams related to assets sold digitally and is a one stop solution to all their day to day problems regarding the trade of digital assets.

7. References

[1] D. Chirtoaca, J. Ellul and G. Azzopardi, "A Framework for Creating Deployable Smart Contracts for Non-fungible Tokens on the Ethereum Blockchain," 2020 IEEE International Conference on Decentralized Applications and Infrastructures (DAPPS), 2020, pp. 100-105, doi: 10.1109/DAPPS49028.2020.00012.

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