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NFT Sneaker Marketplace Design, Testing, and Challenges

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Abstract—This paper introduces the preliminary background and implementation of the NFT sneaker marketplace. Specifically, we build sneaker NFTs on top of ERC-20 within the Ethereum network and use a top-to-bottom design mechanism. Our website performs well in its functionality, compatibility, and performance. We discuss possible future steps for security implementation. In particular, we recommend using a cold wallet for clients' transactions and implementing multi-signature contracts to avoid spoofing and repudiation. Introducing the sneaker NFT marketplace will vastly reduce the costs of transactions and delivery time in the physical sneaker marketplace. We hope investors in the physical asset space can find a faster, easier, and cheaper way to trade physical assets.

Index Terms—NFT Marketplace, Ethereum, Blockchain, NFT Minting, Smart Contract, Sneaker

I. INTRODUCTION

NFTs have the potential to radically change the book industry. We are offering a unique NFT package to test the waters and see what works best to create value for the buyer. This could provide a new revenue stream for every book.

– Robert Pozen, Senior Lecturer, MIT Sloan

On October 1, 2021, senior lecturer Robert Pozen from MIT Sloan opened his NFT auction on the OpenSea platform. The auction winner will receive a 3D NFT of a new cover and a new preface with Pozen's digital signature. In addition, the winner will receive an hour of free consulting with Pozen and a free seat in his related upcoming MIT Sloan Executive Education class, Maximizing Your Productivity: How to Become an Efficient and Effective Executive [1]. NFTs have been around for a while; however, 2021 has seen several high-profile sales, including the \$69.3 million Christie's sale

Special thanks to Professor Ying Li for help and guidance writing this thesis. I have learned a lot throughout the process.

of the NFT associated with Everyday: the First 5000 Days — a digital artwork by the US artist Beeple. Figure 1 also shows the market capitalization of transactions globally involving an NFT rising from 40.96 million dollars in 2018 to 338.04 million dollars in 2020. So what is an NFT? In short, NFTs are tokens that we can use to represent ownership of unique items. They let us tokenize things like art, collectibles, and even real estate [2]. Recently, LuxFi launched the first asset-backed NFT marketplace for luxury products. To link NFTs with physical assets, they used a product fingerprint technology so that users can scan the QR code/NFC tag of the items and view the history of each item. With personal experience in trading sneakers, the buyer must pay an additional 6% processing fee, including processing and verification service, \$14.95 flat shipping cost, and sales taxes depending on buyer and seller location. The seller also needs to pay 10% of transaction fees and 3% of the payment processing fee from the selling price. Hence, the introduction of NFT can reduce the commission fees and reduce the delivery time significantly.

There are many current NFT marketplaces existing, such as OpenSea. OpenSea is one of the largest NFT marketplaces. The platform facilitates creating, buying, and selling NFTs. It is also called the 'eBay' of NFTs, catering to more than 600,000 users and hosting 2 million collections comprising 80 million NFTs. The platform gives a quick tutorial if you are a first-time NFT collector. OpenSea supports images, video, 3D, and music. [5] Inspired by OpenSea, our NFT sneaker marketplace connects physical sneakers with NFTs to allow sneakers' investors to have a faster transaction. This paper will introduce the mechanism behind an NFT marketplace, technology stacks used in the project, and testing procedures of our platform.

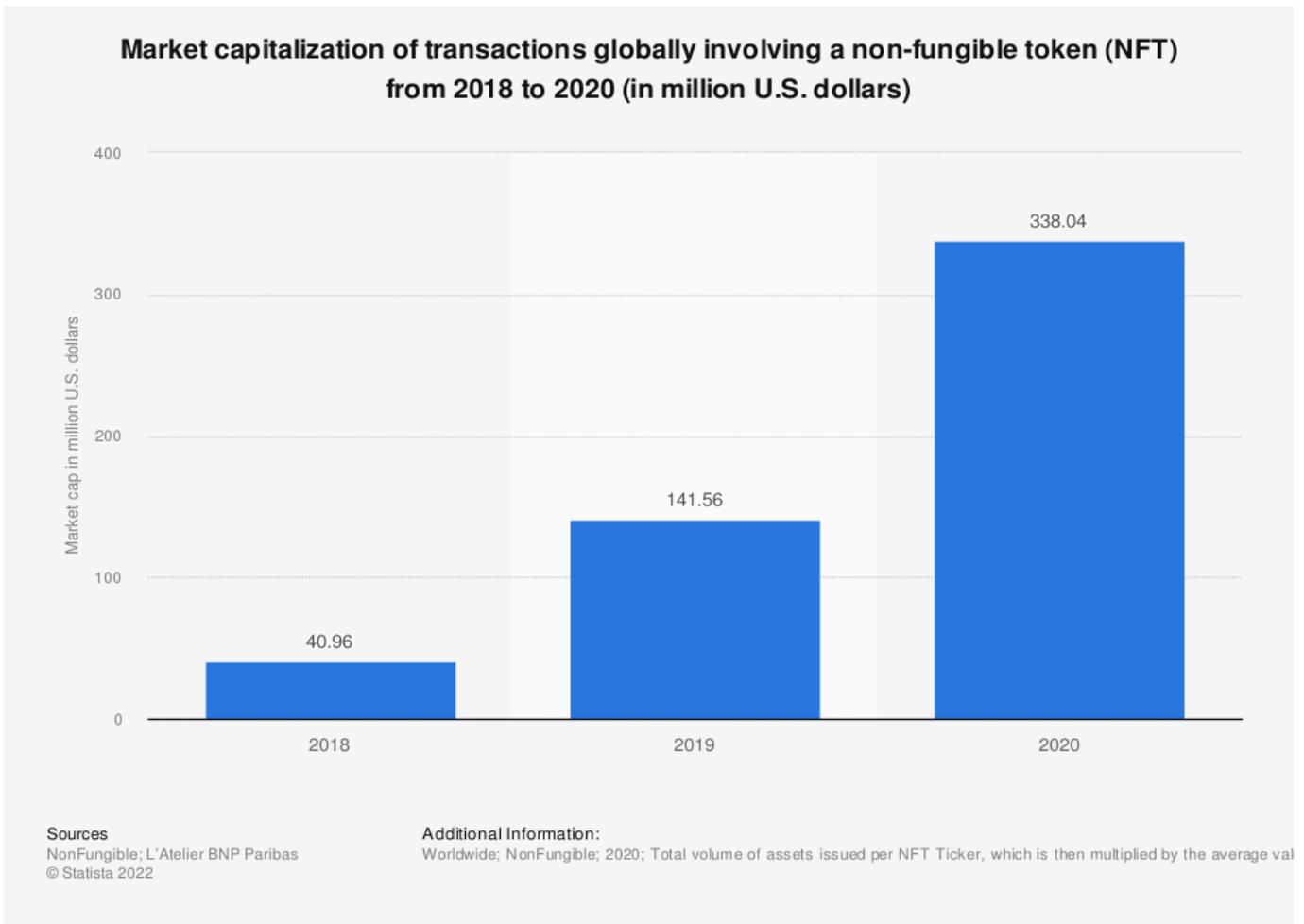


Fig. 1. NFT Development

II. PRELIMINARY BACKGROUND

To build an NFT sneaker marketplace, we will first introduce technical terms that connect the marketplace together.

A. Blockchain

According to IBM, Blockchain is a shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network. An asset can be tangible (a house, car, cash, land) or intangible (intellectual property, patents, copyrights, branding). Virtually anything of value can be tracked and traded on a blockchain network, reducing risk and cutting costs for all involved. [12] Blockchains are built based on two primary consensus mechanisms — Proof-of-Stake (PoS) and Proof-of-Work (PoW). Proof of work is the original crypto consensus mechanism, first used by Bitcoin. Proof of work and mining are closely related

ideas. It is called “proof of work” because the network requires considerable processing power. Proof-of-work blockchains are secured and verified by virtual miners worldwide racing to be the first to solve a math puzzle. The winner gets to update the blockchain with the latest verified transactions and is rewarded by the network with a predetermined amount of crypto. [3] The advantage of the proof-of-work mechanism is that it is very secure; however, at the same time, it is also an energy-intensive process to scale. We will discuss the pros and cons of such a mechanism later, as Ethereum-based NFTs use the PoW consensus mechanism. Ethereum has been to build an entirely new ETH2 blockchain, which uses the Proof of Stake consensus mechanism and begins rolling out in December 2020 and should be finished in 2022. In the proof-of-stake system, validators (the proof-of-stake equivalent of miners) are chosen to find a block based on the number of tokens they hold rather than having

an arbitrary competition between miners to determine which node can add a block. So it uses very little energy to secure a blockchain, which is more environmentally friendly.

B. NFT Minting

Minting an NFT is how your digital art becomes a part of the Ethereum blockchain—a public ledger that is unchangeable and tamper-proof. Similar to how metal coins are minted and added into circulation, NFTs are also tokens that get “minted” once they are created. Your digital artwork is represented as an NFT, so it can then be purchased and traded in the market and digitally tracked as it is resold or collected again in the future. Specifically, in our project, we will use ERC-20 to mint our NFTs. The ERC-20 introduces a standard for Fungible Tokens; in other words, they have a property that makes each Token be precisely the same (in type and value) as another Token. For example, an ERC-20 Token acts like the ETH, meaning that 1 Token is and will always be equal to all the other Tokens. [4] The ERC20 Token Standard defines a set of rules that apply to all ERC20 tokens, which allow them to interact with each other easily. ERC20 makes it easy for someone to mint their tokens that will have interoperability with others on the Ethereum blockchain.

C. Smart Contract

Smart contracts are simply programs stored on a blockchain that run when predetermined conditions are met. They typically are used to automate the execution of an agreement so that all participants can be immediately certain of the outcome, without any intermediary’s involvement or time loss. They can also automate a workflow, triggering the next action when conditions are met. Smart contracts work by following simple “if/when...then...” statements that are written into code on a blockchain. A network of computers executes the actions when predetermined conditions have been met and verified. These actions could include releasing funds to the appropriate parties, registering a vehicle, sending notifications, or issuing a ticket. The blockchain is then updated when the transaction is completed. That means the transaction cannot be changed, and only parties who have been granted permission can see the results. Then the smart contract can be programmed by a developer – although increasingly, organizations that use blockchain for business provide templates, web interfaces, and other online tools to simplify structuring smart contracts. [13]

In the context of NFTs, the smart contract contains information regarding the NFT including the creator of the work, other parties’ entitled to royalties each time the NFT is sold, and the ownership history of the work. So with NFTs associating to physical sneakers, we need information such as shoes size, color, brand, transaction history, and owners.

III. METHODOLOGY & WEBSITE STRUCTURES

The technology stacks we are going to use are React, Ethers.js, Solidity, Metamask, and Hardhat.

Reach serves as the client framework for the NFT marketplace. When building smart contracts, we will need a way to deploy the contracts, run tests, and debug Solidity code without dealing with live environments. We will also need a way to compile our Solidity code into code that can be run in a client-side application. Hardhat is an Ethereum development environment and framework designed for full stack development. Ethers.js is the Ethereum web client library. Metamask helps to handle account management and connecting the current user to the blockchain. MetaMask enables users to manage their accounts and keys in a few different ways while isolating them from the site context. Once a user has connected their MetaMask wallet, the developer can interact with the globally available Ethereum API (window.ethereum) that identifies the users of web3-compatible browsers (like MetaMask users), and whenever you request a transaction signature, MetaMask will prompt the user in as comprehensible a way as possible.

The project includes four different pages for sneaker NFT marketplace. They are home page, digital asset minting page, my digital asset page, and creator dashboard. Figure 2 shows the sneaker NFTs minting page. As a template, user can add asset name and asset along with an asset price in ETH. In practice, if user has a pair of physical shoes, one needs to send the shoes for authentication. After the authentication process, our platform would generate a contract and address for this sneaker-backed NFT to trade.

Figure 3 shows the NFT workflow in details. Our project uses a top to bottom design mechanism. Hence, we first allow NFT owner checks that the title and shoes description are completely accurate by allowing them inputting descriptions themselves. Then, the user digitizes the raw data into a proper format and the asset will go through an authentication process. The NFT owner stores the raw data into an external database outside the blockchain. After authentication, the NFT owner will sign a transaction, including the hash of NFT

Sneaker NFT Marketplace

No file chosen

Fig. 2. Minting NFT Sneaker

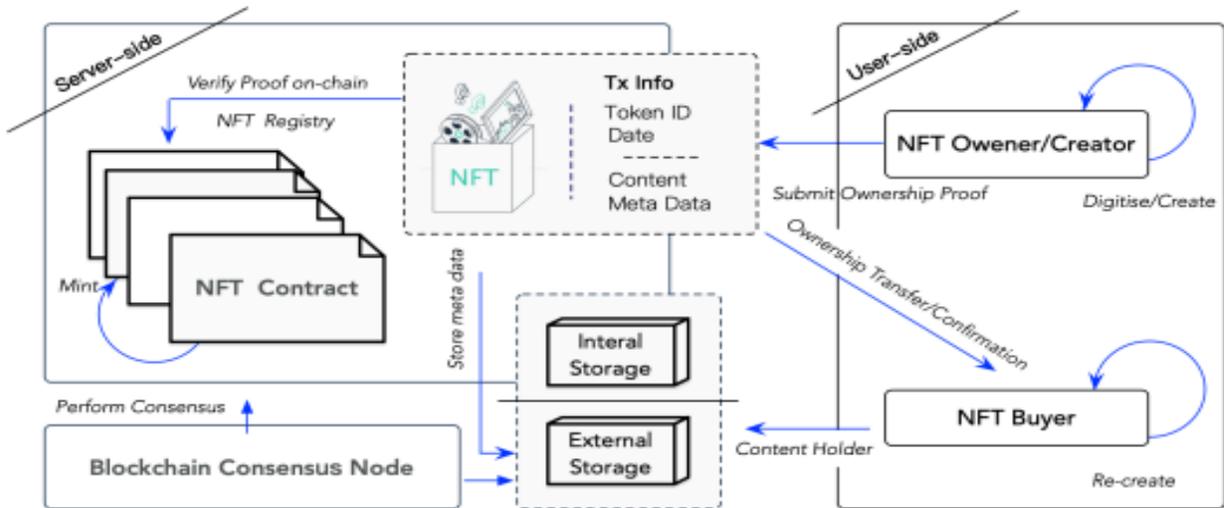


Fig. 3. NFT Workflow

data, and then sends the transaction to a smart contract. After the smart contract receives the transaction with the NFT data, the minting and trading process begins. Once the transaction is confirmed, the minting process completes. By this approach, NFTs will forever link to a unique blockchain address as their persistence evidence.

IV. SYSTEM STUDY

After implementing the website, we will use our website and NFT framework as a guideline to conduct

five areas of studies discussed in this section. Figure 4 shows the overall study procedures.

A. Functional Study

Functional study is a quality assurance (QA) process and a type of black-box study that bases its cases on the specifications of the software component under test. Functions are tested by feeding them input and examining the output. [6] For our purposes, we test the identification of functions of the home page, creating/minting

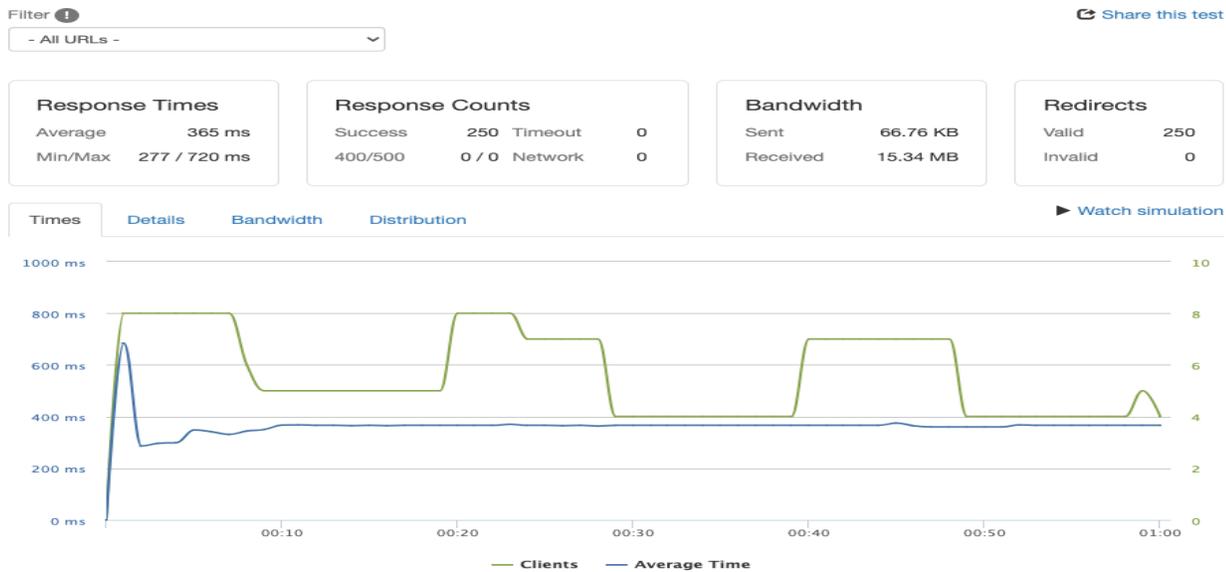


Fig. 6. Loading Test

1) *Spoofing*: Spoofing is the ability to impersonate another entity (for example, another person or computer) on the system, which corresponds to authenticity. When a user interacts to mint or sells NFTs, a malicious attacker may exploit authentication vulnerabilities or steal the user's private key to transfer the ownership of NFTs illegally. Thus, it is recommended to have a formal verification for the NFT smart contract and to use the cold wallet to prevent private key leakage. A cold wallet is a cryptocurrency storage solution that is not connected to the Internet. They are also called Hardware wallets and use a physical medium — typically in the shape of a USB stick. It is considered the most secure type of wallet because it would require hackers to have access to your device and the associated PIN/Password. [7]

2) *Non-Repudiation*: Non-Repudiation refers to the situation where the author of a statement cannot dispute, which is related to the security property of nonrepudiability. Non-repudiation means that participants cannot deny the transaction and behavior in the transaction of E-commerce in the blockchain. The purpose of non-repudiation service is to collect, maintain, provide, and verify the undeniable evidence about messages from the transmitter to the receiver. The non-repudiation service may involve the services of the trusted third party, called the delivery authority (DA). [11] In particular, the fact that a user sends NFT to another user cannot deny. This is guaranteed by the security of the blockchain and the unforgeability property of a signature scheme. However,

the hash data may be tampered by a malicious attacker, or the hash data may bind with an attacker's address. Thus, we could use a multi-signature contract can partly solve this issue since each binding must be confirmed by more than one participant. Hence, our platform can serve as a middle ground to facilitate transactions between users.

V. CHALLENGES OF NFT MARKETPLACE

In the section, we will discuss potential challenges in developing sneaker NFT marketplace. Because our NFT schemes are built on top of Ethereum. It is obvious that the main drawbacks of Ethereum still exist. First, the NFT systems generally have slow confirmation time. Bitcoin reaches merely 7 TPS (Transactions per Second) while Ethereum only 30 TPS. However, those centralized databases are already capable of handling thousands of transactions each second. VISA, for example, handles around 1,500-2000 transactions each second. Decentralization comes at the cost of performance and security. [8] But for our purpose, the wait time is still faster than physical delivery, which usually takes seven to nine days to complete.

Other than slow confirmation, high gas prices have become a major problem for NFT marketplaces, especially when minting the NFTs at a large scale that requires uploading the metadata to the blockchain network. Every NFT-related transactions are more expensive than a simple transfer transaction because smart contracts involve

computational resources and storage to be processed. Minting an NFT token costs over USD 50. To complete a simple NFT trade can run between USD 60 and USD 100 for each transaction. Expensive fees caused by complex operations and high congestion greatly limit its wide adoption. [10]

Similar to the situations of most cryptocurrencies, NFTs also confront the barriers like strict management from the government. On the other side, how to properly regulate this nascent technology with the corresponding market is also a challenge. In some countries, such as Indian and China, the legal situation is strict for cryptocurrencies, and also for NFT sales. Exchanging, trading, selling, or buying NFTs have to overcome the difficulties of governance. Several countries, such as Malta and France, are trying to implement suitable laws with the aim to regulate the service of digital assets. Therefore, undertaking due diligence is a necessity before investing serious tokens in NFTs. In addition, IP-related products (including arts, books, domain names, etc.) are treated as taxable property under the current legal framework. However, NFT-based sales stay out of this scope. Hence, tax implementation is also a factor for us to consider when implementing NFT marketplace.

VI. FUTURE WORK AND CONCLUSION

Overall, this paper introduces the preliminary background and implementation of the NFT sneaker marketplace. Specifically, we build sneaker NFTs on top of ERC-20 within the Ethereum network and use a top-to-bottom design mechanism. NFT owner checks that the title and shoe description are entirely accurate by allowing them to input descriptions themselves. Then, the user digitizes the raw data into a proper format, and the asset will go through an authentication process. The NFT owner stores the raw data in an external database outside the blockchain. After authentication, the NFT owner will sign a transaction, including the hash of NFT data, and then sends the transaction to a smart contract. After the smart contract receives the transaction with the NFT data, the minting and trading process begins. Once the transaction is confirmed, the minting process completes. NFTs will forever link to a unique blockchain address as this approach evidences their persistence. After implementing the website, we conduct functional, interface, compatibility, performance, and security studies. Our website performs well in its functionality, compatibility, and performance. We discuss possible future steps for security implementation. In particular, it is recommended to use a cold wallet

for clients' transactions and implement multi-signature contracts to avoid spoofing and repudiation. Future work will consider those factors and design a security system that connects all elements. Lastly, the NFT marketplace still has a long way to develop in its slow confirmation, high gas fees, and government regulations.

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