NFT based Fundraising System for Preserving Cultural Heritage: Heirloom

Emre Ertürk
Department of Computer Engineering
Muğla Sıtkı Koçman University
Mugla, Turkey
emreerturk3@posta.mu.edu.tr

Murat Doğan
Department of Computer Engineering
Muğla Sıtkı Koçman University
Mugla, Turkey
muratdogan5@posta.mu.edu.tr

Ümit Kadiroğlu
Department of Computer Engineering
Muğla Sıtkı Koçman University
Mugla, Turkey
umitkadiroglu@posta.mu.edu.tr

Enis Karaarslan
Department of Computer Engineering
Muğla Sıtkı Koçman University
Mugla, Turkey
enis.karaarslan@mu.edu.tr

2021 6th International Conference on Computer Science and Engineering (UBMK) | 978-1-6654-2908-5/21/$31.00 ©2021 IEEE | DOI: 10.1109/UBMK52708.2021.9559006

***Abstract*—Cultural heritage assets are in danger of extinction or damage due to lack of publicity and financial problems. Technological advances can play a role in their preservation and promotion. This study aims to create a blockchain-based cultural property protection system which we named the Heirloom. The proposed system uses blockchain and IPFS. This system will allow foundations to receive funding to protect cultural assets without using an intermediary. The cultural assets are transformed into unique digital items using the NFT (Non-Fungible Token) technology. The metadata of the created NFTs is stored in the distributed file system IPFS (InterPlanetary File System). An autonomous working system is provided with smart contracts. The supporters give donations to earn their share of protection and maintenance rights. The proof of concept implementation is promising. A case study on protecting old olive trees in Milas has also started with a local foundation. Possible outcomes will be the ease of getting funds for preserving cultural heritage and increasing awareness. Future studies will include working on different methods for decreasing the costs of the system and integrating augmented and virtual reality technologies.**

***Index Terms*—Cultural Heritage, Fundraising, NFT, Blockchain, IPFS, Smart Contract**

I. Introduction

Cultural heritage is the tangible, intangible, and natural classified values that act as bridges from the past to the present. They emerge as a result of the lifestyles of a society or the characteristics of a geographical region. However, at the same time, they express meaning and richness for all humanity, not only for a particular society. It strengthens the solidarity in the communities and regions where they exist and adds meaning to their togetherness. It allows people to connect with their past and feel a sense of belonging.

The protection of these values is so important for humanity. The World Heritage program initiated by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) plays an essential role. There are 1121 listed heritage sites in 167 countries as of January 2021; 869 of which are cultural, 213 are natural, and 39 are mixed [1]. These heritage sites contribute to the economic and social development of the local area they are located in, as these places are advertised worldwide. In this way, the tendency of the people to protect their cultural heritage increases; assets are preserved for future generations.

However, not every cultural heritage can get the value it deserves. Sometimes, they are not even detected. These assets face many dangers, such as being damaged and destroyed. This study proposes a decentralized system that can be used for fundraising. This system will help in the discovery, promotion, and maintenance of cultural assets. Decentralized technologies such as blockchain and NFT are used. The system has an economic model by which the donation revenues are transferred to foundations and asset hosts transparently.

In the next section, fundamentals are explained. Related works are given in section 3. The proposal of the system is explained in section 4, implementation in section 5. Finally, results and conclusions are given.

II. Fundamentals

A. Protection of Cultural Assets

Many cultural heritages have not yet been identified or appreciated and face many dangers. These dangers can be listed as follows:

- Deterioration of structure and material properties
- Human interventions that will disrupt the integrity of assets
- The negative impact of climatic and environmental elements on assets
- Armed conflicts and acts of terrorism
- Incomplete or inadequate management plans

Our case study is on old olive trees. There is an old olive tree on the Greek island of Crete, estimated to be 4000 years [2]. This tree attracts more than 20,000 tourists to the region every year. Milas/Muğla that is on the other side of the sea hosts more than one hundred old olive trees. Study [12] shows that one of which has been alive since the bronze age.

978-1-6654-2908-5/21/$31.00 ©2021 IEEE

However, these trees are not fertile as the young trees. The low productivity rate of these trees is not beneficial for the people of the region who make their living from olive cultivation. This project can make a change by helping in preserving these old trees.

This project can also be extended to identify and protect many other endangered cultural assets. There are some foundations and organizations established to raise awareness and protect cultural heritage. These foundations and organizations protect areas, structures, and natural heritage for future generations by taking them under protection. However, many cultural assets continue to exist in the world that we have not yet realized. It is necessary to create an economic model for the emergence, promotion, tourism, and maintenance costs of these cultural assets.

B. Blockchain and NFT

Blockchain technology consists of blocks in a chain structure where each block is secured by cryptography techniques to maintain the integrity of the records. These blocks hold transactions, the hash of the current block, and the previous block's hash. In addition, a block may contain program codes (smart contracts) that enable a system to operate autonomously [3].

The uses of blockchain technology, which is famous for Bitcoin [4], are not limited to cryptocurrencies. Many companies and institutions have started to use blockchain technology in supply chain management, authentication, and healthcare. NFTs (Non-Fungible Tokens) [5] work on the blockchain and are created with specified standards. These NFTs are unique digital assets. Unlike tradable tokens, they are non-exchangeable, making them one of the best ways to identify an asset uniquely. NFTs can be used for many assets such as digital arts, game items, and collectibles. In our project, we are using it for digital assets of cultural heritages.

C. IPFS

NFTs are created through smart contracts. They have data called metadata. The metadata can consist of different types of data, such as pictures, names, and descriptions. Descriptions are the information that defines the NFTs, each of which is unique. The blockchain is not suitable for storage purposes due to its nature. We store these data in the IPFS (InterPlanetary File System), which is suitable for storing large amounts of data. IPFS [6] is a distributed file system that is designed to make the web faster, safer, and more open [7]. IPFS solves the existing problems with HTTP and aims to create a flexible internet.

III. Related Works

The difficulties in the digitization of cultural heritages are explained in Huang's [8] study. In Mofokeng's work [9], a system with NFT technology is developed for the protection of endemic animal species. These are in danger of extinction as a result of the deteriorating nature of Africa. The work of the KHHN team [10], aims to protect cultural heritages in Korea through NFTs. Table 1 shows the comparison of these solutions and our solution. Our project differs from these by including foundations and defining an active role in the system. We are also creating a more inclusive economic model. In addition, we aim to preserve the decentralized and distributed structure by incorporating the strengths of the IPFS (InterPlanetary File System) distributed file system into our project.

TABLE I
Comparison of Heirloom with Other Solutions

	Collaboration with foundations	***Blockchain and NFT***	***IPFS***
Mofokeng	No	Yes	No
KHHN	No	Yes	Yes
Heirloom	Yes	Yes	Yes

IV. System Proposal

A. System Processes

Heirloom is a decentralized system that consists of the DApp (decentralized application), smart contracts, blockchain, and the IPFS distributed file storage technologies. The Heirloom system architecture is shown in Figure 1. The autonomous operation of the system, as shown in Figure 1, is as follows:

1) The foundations construct the verification check and protection agreements of the cultural assets.
2) Assets are converted into NFTs by foundations.
3) The generated NFTs are displayed in the online marketplace.
4) Supporters access the market through the decentralized application and can donate for the cultural assets.
5) The income obtained after the purchase (sale of protection rights) transaction is transferred to the foundations. At this stage, the supporter is asked to donate to the Heirloom system for the system's sustainability as our nonprofit system will survive through donations.
6) Regular (monthly) payments are made to asset hosts or responsible institutions according to the terms set in the smart contracts.

B. System Actors

The users of the system are the foundation, asset host, supporter and the manager. Foundations determine the assets to be protected. Every foundation has the authority to make "minting", which is used to create digital assets. Foundations make agreements with asset hosts on necessary conditions (maintenance of the real asset). The asset host is the actor who hosts cultural heritages. These values belong to society, not to an individual. This actor may also be an institution that takes responsibility for the protection or maintenance of

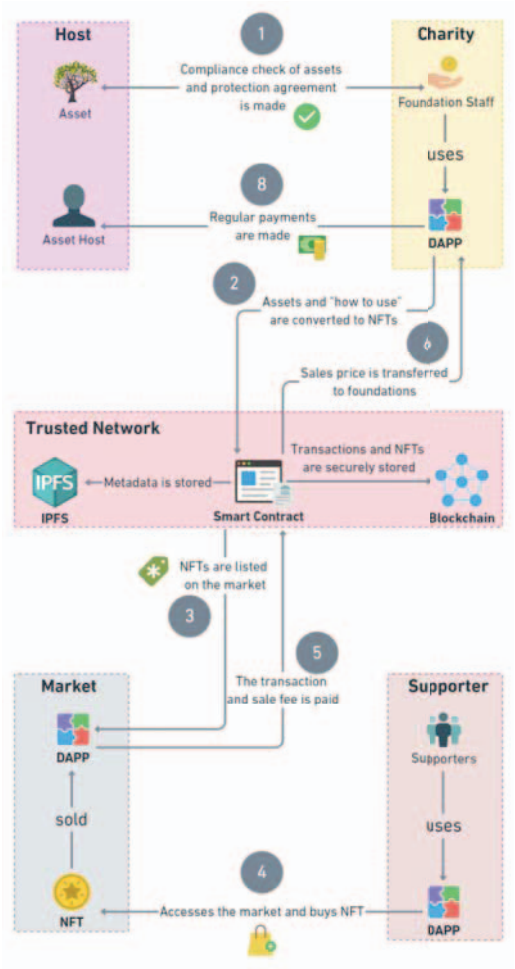

Fig. 1. Heirloom system architecture

the asset. This actor will receive regular payments for the protection of the assets. The conditions of the agreement and a smart contract will be formed according to the agreement. The supporter; supports the protection and maintenance of cultural assets. The manager is the most authoritative actor of the system, authorizing foundations and making mintings.

C. Smart Contracts

Heirloom works through smart contracts. The basic smart contract functions are NFT creation, NFT purchasing and NFT viewing. There are three primary roles in the system: ADMIN, MINTER, and USER. Charities and foundations with the MINTER role can use the minting function to create the asset to be protected. Users with the ADMIN role determine who can have the MINTER role. The minting function enables the creation of an asset. For this function, a hash value containing a user address and the asset's metadata is sent. A tokenID is automatically generated for the asset.

The token purchase takes place via the buy function. This function takes tokenID as a parameter. After verifying the token's existence with the tokenID, the purchase is made by changing the host of the asset with the transfer function. Metadata of the token is returned with the TokenURI function. This function takes tokenID as a parameter. With these returned values, tokens are displayed on the market.

V. Implementation

Our smart contract is prepared in ERC-721 [11] standards and contains the basic functions required for an NFT market application. The communication of our system with IPFS was carried out with the NFT.storage library. The Web3.js library and the Metamask plugin are used for the user interface to communicate with our smart contract uploaded to the Rinkeby testnet. Users can perform their transactions on the blockchain network via smart contract and donate to cultural heritage reliably as all records are immutable and traceable.

Figure 2 shows the page with the NFTs displayed on the Heirloom. Supporters access the assets they want to donate from this page. The NFT creation page is shown in Figure 3. Users with the MINTER role can access this page.

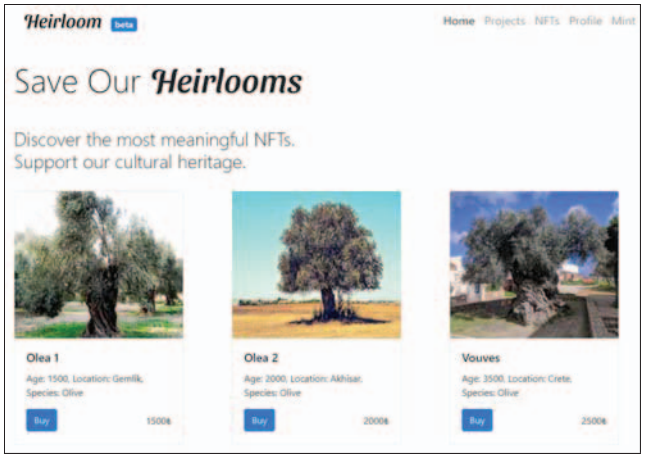

Fig. 2. Heirloom NFTs page

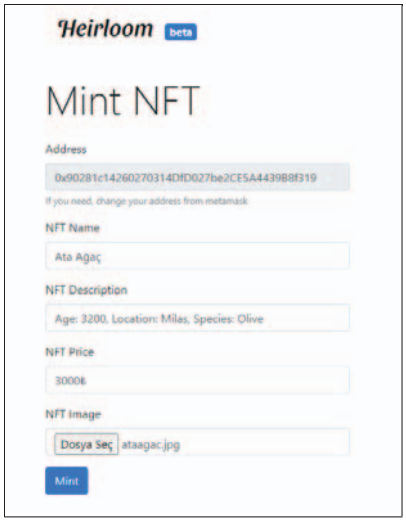

Fig. 3. Heirloom minting page

The prototype of the system is implemented on Ethereum's Rinkeby Testnet and Avalanche's Fuji Testnet. Purchasing and creating new NFTs functions and smart contracts that allow the system to operate autonomously have been tested on these networks. The gas fee required for the contract deployment and the minting process is determined. The comparison is with the current values of the AVAX and ETH cryptocurrencies. Table 2 shows the comparison of the contract deployment operation, and table 3 shows the comparison of the minting operation.

TABLE II
COMPARISON ON HEIRLOOM SMART CONTRACT DEPLOYMENT

	Fuji Testnet (Avalanche)	***Rinkeby Testnet (Ethereum)***
Gas Limit	3,877,016	
Gas Price	225 nAVAX	16 Gwei
Gas Fee	0.872329 AVAX ($9.35)	0.062032 ETH ($117.30)
Average Deployment Time	6.55 ms	131,000 ms

TABLE III
COMPARISON ON HEIRLOOM ASSET MINTING

	Fuji Testnet (Avalanche)	***Rinkeby Testnet (Ethereum)***
Gas Limit	214,759	
Gas Price	225 nAVAX	16 Gwei
Gas Fee	0.048321 AVAX ($0.51)	0.003436 ETH ($6.49)

VI. RESULTS AND CONCLUSION

We have developed the Heirloom; the system that uses decentralized technology and a distributed file system to protect and promote cultural heritage. We proposed an economic model to protect the cultural heritage with donations made by supporters. The foundations play a role, and asset hosts are supported. NFT technology is popular nowadays, and we wanted to use it for social good. It is aimed to draw attention to cultural heritage protection and increase awareness. Source codes of the Heirloom can be found on the project GitHub page (https://github.com/saveourheirlooms/heirloom).

The first use case was focused on protecting the old olive trees. We worked with a new foundation which is being established in Muğla. An alternative tourism model will also be established in this region.

Our solution is implemented and tested on Ethereum and Avalanche platforms. Ethereum is the platform where NFT market applications are widely used, but transaction fees are above reasonable levels on Ethereum. The transactions were carried out faster on Avalanche and the fees were more reasonable. This can show that NFT implementations can have different alternative platforms. However, more tests on reliability, sustainability, and security have to be performed.

Future works will include studies on using layer 2 Ethereum solutions. These are for scaling applications by handling the transactions outside the Ethereum mainnet (off-chain), while keeping the secure features of the Ethereum. We will also test other platforms for low-fee environments that provide carbon-neutral, sustainable functions for NFTs. Also, different methods will be tested for more economical NFT solutions. It is also aimed to integrate augmented and virtual reality technologies into this system to make it possible for tourists to easily perform support transactions while visiting the places where the assets are located.

REFERENCES

[1] Unesco, (2021) World Heritage List. Access address https://whc.unesco.org/en/list/

[2] Kostelenos, G., & Kiritsakis, A. (2017). Olive tree history and evolution. Olives and Olive Oil as Functional Foods: Bioactivity, Chemistry and Processing; Kiritsakis, A., Shahidi, F., Eds.

[3] Karaarslan, E. Konacakli, E. (2020). Data Storage in the Decentralized World: Blockchain and Derivatives. In Gulsecen S., Sharma S., Akadal E. (Eds.), Who Runs The World: DATA (pp. 37-69). Istanbul, Istanbul University Press

[4] Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. Decentralized Business Review, 21260.

[5] Wang, Q., Li, R., Wang, Q., & Chen, S. (2021). Non-fungible token (NFT): Overview, evaluation, opportunities and challenges. arXiv preprint arXiv:2105.07447.

[6] Benet, J. (2014). Ipfs-content addressed, versioned, p2p file system. arXiv preprint arXiv:1407.3561.

[7] Wüst, K., & Gervais, A. (2018, June). Do you need a blockchain?. In 2018 Crypto Valley Conference on Blockchain Technology (CVCBT) (pp. 45-54). IEEE.

[8] Huang, W., & Dai, F. (2019). Research on digital protection of intangible cultural heritage based on blockchain technology. Information Management and Computer Science (IMCS), 2(2), 14-18.

[9] Mofokeng, N., & Fatima, T. (2018). Future tourism trends: Utilizing non-fungible tokens to aid wildlife conservation. African Journal of Hospitality, Tourism and Leisure, 7(4).

[10] Korea Heritage and History NFT. (2021). Access address https://devpost.com/software/korean-heritage-and-history-nft

[11] ERC-721 Token Standard. (2018). Access address http://erc721.org/

[12] Şahiner, E., Polymeris, G. S., Atlihan, M. A., Aktürk, S., & Meriç, N. (2020). Indirect dating of an olive tree planting event using luminescence of the sediments lying beneath the roots of the tree: a pilot study in the south-western part of Anatolia, Turkey. Journal of Quaternary Science, 35(5), 706-715.