

Application of Blockchain Technology and NFTs in a Museum Environment

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Abstract - Museums as traditional institutions are usually not leaders in the use of the latest and disruptive technologies. However, the Covid-19 pandemic has influenced the growing interest of researchers and museum experts in new solutions for communication and museum operations. That is how blockchain technology and non-fungible tokens (NFT) entered the focus of museums. Although it is most often associated with cryptocurrencies, this technology, due to its main property, the immutability of records on the chain, has great potential for use in various aspects of museum work.

This paper will show how blockchain and NFTs can be used in museums, from checking the provenance, ownership, and authorship of museum objects, facilitating their borrowing, more efficient digital rights management to building smart museums. It will also focus on how museums have so far experimented with NFTs and blockchain technology and highlight the potential problems of their use. Huge challenges to understanding and adopting this technology is the lack of knowledge base and this paper aims to bring the topic of blockchain technology within the museum field to the table and start a conversation on this fast-growing new technology and possibilities of its implementation.

Ključne riječi – blockchain technology, NFT, museums, galleries, art, cultural heritage

I. INTRODUCTION

Blockchain is a distributed ledger that contains time-stamped records organized into blocks, which are interconnected by repeating a hash code as the first part of one block and the last part of the previous one [1]. In other words, it is a database on a distributed network, a copy of which is kept by all nodes on the network. The security of the records on the ledger is one of the main features of this technology and sharing the ledger with all nodes on the network prevents data modification.

Although blockchain technology is usually associated with the emergence of the cryptocurrencies, it was created much earlier. Wanting to investigate trust in information in the digital age, Stuart Haber and Scott Stornetta developed a computer system in 1991 that could digitally time stamp any document through cryptographic

coding (hashing) [2]. However, it was not until 2008 that the blockchain gained popularity thanks to the white paper of the Bitcoin, published by an unknown individual or collective under the pseudonym Satoshi Nakamoto [3]. The next big step in the development of the technology was the emergence of the Ethereum blockchain in 2013 and the presentation of the new Ethereum protocol in 2014 [4]. The new blockchain made it possible to create applications and smart contracts which have enabled tokenization, the process of turning an asset into a digital token which represents that asset [5]. Thus, non-fungible tokens were developed on the Ethereum chain, whose popularity skyrocketed in 2021 after the sale of Beeple's NFT *First 5000 days* for \$69 million at Christie's auction. Unlike classic cryptocurrencies where every coin is equal, NFT is unique, each has its own value and therefore cannot be exchanged for one another, hence the name non-fungible. NFTs use smart contracts, which Ethereum adapted for use on the blockchain and which enables two parties to perform a secure exchange, without intermediaries [6].

Due to the aforementioned features, blockchain has been increasingly explored in the last few years to exploit its potential in sectors such as finance, commerce, medicine, etc. However, this new technology could also be useful in the heritage sector. Classical heritage institutions are usually not pioneers of new technologies, but despite this, researchers have already begun to study this topic. Although there are not that many published papers, they provide a useful insight into current thinking on blockchain, NFTs and cultural heritage.

Methodologically, this paper is based on literature review and the analysis of external content. The main research question was what are all the possible uses of blockchain and NFTs in the museum environment? From that question arose sub-questions such as: can some museum practices be simplified and improved by using new technology? What are the obstacles in its use? How have museums interacted with this technology so far?

The main part of the paper refers to the application of blockchain and NFTs in museums and is divided into

several sub-chapters, each of which is dedicated to one of the possible uses. In each part, the main conclusions from the literature will be presented, along with projects carried out so far. Also, some problematic aspects of its use are explored, and we raise questions that open up space for new research. The following is a discussion in which we will refer to the context in which research on this topic occurs. Also, we highlight still unexplored or under-researched phenomena related to this technology in museums. We will give our final thoughts on the subject in the conclusion of this paper.

II. APPLICATION OF BLOCKCHAIN TECHNOLOGY AND NFTS IN A MUSEUM ENVIRONMENT

In the last few years, various research has been conducted on how blockchain technology can be used to improve the work of heritage institutions, including museums. One study from 2022 showed that a search of articles published in the last 10 years on the topic of blockchain technology and cultural heritage highlighted three thematic units: verification of provenance and authenticity, tokenization and fractional capital, and management of intellectual and digital rights [7]. However, a review of the literature revealed that the scope of research is much deeper, and the ideas are more diverse. So far, there are several projects and platforms that have taken advantage of this technology and NFTs to explore their possible benefits in heritage field.

TABLE 1 TECHNOLOGY USED IN DIFFERENT APPLICATIONS

Application in a museum field	Blockchain technology	NFT
A. Provenance, authenticity, authorship, and ownership	✓	✓
B. Digital database of museum objects	✓	
C. Museum rights management	✓	✓
D. Loan of museum objects	✓	
E. Shared ownership and guardianship	✓	✓
F. Smart museum	✓	
G. Making profit	✓	✓

A. Provenance, authenticity, authorship, and ownership

The most common use of NFTs and blockchain technology in research so far is the verification of authorship, authenticity, ownership, and provenance of works of art [1], [8], [9], [10], [11], [12]. Museums and galleries spend a lot of time verifying the provenance of objects from their collections, as well as when buying or selling artworks. A public registry of artworks and museum collections with the mentioned information could therefore be located on the blockchain, which would be accessible to everyone, and every change of owner would be recorded. This would ensure a secure record that is immune to tampering. However, there is a question of the accuracy of the original data entered on the chain, which may be wrong. This is especially the case for, for example, paintings by old masters for which the provenance has not been determined with certainty, so

even the record on the blockchain would not be credible [13].

There are several blockchain platforms that deal with issuing certificates of authenticity for artworks and valuables. The first such platform is Verisart, founded in 2015 and managed by Robert Norton. It is a database of artworks through which a certificate of authenticity can be obtained [1], [9], [14], [15], [16]. The biggest flaw of the platform is that anyone can enter the artwork data, which has led to one absurd certificate. In 2018 Terence Eden entered the *Mona Lisa* on the Verisart chain, signed himself as the author, and put the year of creation as 1506 [17]. Artory is a platform on the Ethereum chain that offers collectors certificates of authenticity of artworks, and they cooperate with galleries, museums, auction houses, etc. [1], [16]. This platform, founded by Nanne Dekking in 2016, solved the problem of freely entering data to obtain a certificate. When an individual wants to enter information about an artwork in the register in order to obtain a certificate, experts from art institutions first must verify entered data, such as provenance. The data about artwork enters the blockchain only after approval from the experts, thus ensuring that only verified and accurate information is recorded on the chain. Artory is also the first company that organized an auction through the blockchain, in cooperation with the auction house Christie's. The third platform that deals with the issuance of certificates via the blockchain is Codex Protocol, which enables the verification of the authenticity and provenance of collectible items and the entry of one's own items into the register. To verify the information that is at the beginning of the chain and on which the others are built, they cooperate with auction houses [1], [16].

When we talk about using blockchain technology to authenticate a work of art or a collectible, one question remains open, and that is how to connect the record on the chain and the physical work [13].

B. Digital database of museum objects

Blockchain could be used to create a digital register of museum collections, but also a register of cultural heritage objects of a region or a country [18], [19], [20]. Photographic and written documentation of objects could be kept on the chain, which becomes especially important in case of destruction or loss of a certain object. Given that the data that would be stored on the distributed ledger is large (4k videos, high resolution images, 3D scans) the blockchain should be separated from the files it manages [18]. One of the suggestions for creating a database is to create a hash of the original document that would represent its digital fingerprint and would be stored on the blockchain. Such a record would ensure the accuracy of the data, and anyone could use the hash to verify its authenticity and immutability [19].

Creating a database of museum objects or heritage objects on the blockchain would ensure greater

transparency of the data and make it impossible for them to be modified later. Also, it would enable greater accessibility of data to other professionals and to the public. However, as with the previous use, there is always the problem of the accuracy of the data entered on the chain.

C. *Museum rights management*

Another use of this technology is management of museum rights and licensing, whether it is the right of ownership, use, display, copyright, or intellectual property right. Museums have an exhibition as well as an educational role and actively participate in the dissemination of knowledge. Therefore, researchers often use museum material to find the necessary information. This process is facilitated by the gradual digitization of museum objects and documentation. The era of Covid-19 pandemic accelerated and increased the digitization of museum collections, as most museums were forced to close their doors and operate exclusively in the digital world. With the digitization of museum collections comes the problem of unauthorized use and sharing of digital content. All this has led to the need for better digital rights management, and the latest solution to this problem is blockchain technology. Three research papers tried to solve the problem with different business models [21], [22], [23]. In order to prevent misuse of museum digital content, first model propose the system of authorizing the use of copyrights based on blockchain, smart contract and cryptography. The research is based on the ECDSA digital signature algorithm [21]. The second paper proposes an algorithm for an authorization mechanism based on blockchain technology that protects the museum's copyrights by using cryptography. This model also includes a cash flow system so that the applicant pays the museum a premium to access the museum's digital content [22]. The third study proposes digital rights management using NFTs and smart contracts. They offer a model in which museums can create NFTs of cultural objects to express their ownership, and the applicant buys an NFT with cryptocurrency to receive a certificate of authorization to use the content [23].

Bhowmik et al. [8] have also made an interesting proposal for digital rights management for lending of digital objects, be it art or archival documents. They propose the creation of a blockchain on which all image transactions will be recorded. The transaction would contain all relevant information about access rules, usage, copyright, etc. An approved transaction receives a hash code, which is then written into the metadata of the JPEG file. Such modified JPEG file is sent to the applicant. The recipient can then verify the authenticity of the file by verifying the record on the blockchain or comparing the signature on the block and in the file they received.

Blockchain technology could also be used to clearly establish certain rights to cultural heritage items, museum objects included, especially those that were dislocated

during war or colonization. This division of rights could contribute to a greater willingness to repatriate alienated objects. With the help of tokenization, the rights over the object could be divided so that one party has the ownership right, while the other retains the exhibition right, permanently, or temporarily. Also, tokenization would facilitate the sharing of the monetary income generated by exhibiting the object or some other activities [24]. In order to prevent the unauthorized removal of objects from the country, objects found at archaeological sites could be immediately entered on the blockchain, and thus the ownership rights could not be called into question [24].

D. *Loan of museum objects*

Another application of blockchain technology concerns the lending of objects among museums [16], [25]. Loans of artworks in museums are regulated by ICOM guidelines and EU provisions, but they often include many other protocols and are often administratively demanding. Loans of museum objects are important both for large institutions and for smaller ones, for whom loans for occasional exhibitions mean a greater influx of visitors and the realization of profits. Therefore, to facilitate the lending process, it is suggested to use blockchain technology. A blockchain can be public, so anyone on the network can see records on it, or private, where only nodes on the private network have access to information. The second option is more suitable for institutions because museums that work together could be connected on a private network. All information about the item, terms of the loan, its time interval, insurance details, value of the item, penalties in case of late return, etc. would be recorded on the chain [16]. Using a smart contract would prevent possible legal problems between museums, because it is automatically executed and charged in the event of a violation of the agreed conditions. Also, other institutions that have access to the network could at any time check where a particular museum object is located and whether it is on loan or in its home institution. This approach would raise the level of security and deepen trust between institutions. The disadvantages of using blockchain technology for loans are on the other hand the high energy consumption, the costs of creating a private chain and the personnel who would maintain it, and the possibility of human error when writing a smart contract. Namely, since smart contracts cannot be changed once they are written on the blockchain, it is necessary to create a new contract to correct incorrect data [16].

This type of loan of museum objects was tested in 2021 among ten museums in Florence. A distributed ledger was created on a private network, which tracked objects that were loaned between museums. Data about each transaction was recorded on the blockchain, including the description of the item, the time interval of the loan, including the start date and end date, insurance details, valuation of the item, verification of the item, the

cost of the loan, if any, and the fee in case of loss or late return of the borrowed object. Given that no smart contract was used, there was no data on monetary transactions. With this project, in addition to a simpler and safer loan of art, the aim was to raise awareness of the rich inventory kept by the museums in Florence [16].

E. Shared ownership and guardianship

Blockchain technology can serve to tokenize artworks and sell them in parts, leading to shared ownership [1], [15], [16], [25], [26]. An example of shared ownership of art is Andy Warhol's painting *14 Small Electric Chairs*, which was partially sold by the Maecenas platform via the Ethereum chain. Namely, in 2018, the platform divided the ownership of the painting into smaller fragments in the form of art tokens, such as NFTs, and released 49% of the shares of the painting for sale. At the auction, they sold 31.5% of the painting [13]. This left them as the majority owners and allowed people to own a piece of art that they otherwise might not have been able to afford. This kind of shared ownership could be implemented in museums as well. Liddell proposes shared guardianship of digital museum objects, which would deepen the connection between the visitor and the institution [15]. The project led by the National Museum Liverpool and the University of Manchester wanted to explore how blockchain technology can be used to create a meaningful digital museum object, i.e., an object that creates values and connections with the participant. The project took place in three phases from 2018 to 2020. In the first phase, project participants took part in various activities, in which, for example, they described the personal items they had brought with them. The second phase was the organization of an online exhibition called *Crypto Connections: Exploring the Personal*, where the participants' personal items and digital museum items selected at the workshops were exhibited, while the third phase included the creation of digital tokens (cryptocollectibles) of the items exhibited at the exhibition. The results of the research showed that blockchain technology has a positive impact on the creation of connections between participants, museum objects and the museum. By owning a digital token, the participants felt a moral obligation towards the objects and the museum, which is one of the prerequisites for joint guardianship of the same. The token served the participants as a form of memorabilia, which reminded them of the entire process and the experiences gained, thereby adding social value [15], [26].

However, when we talk about shared guardianship, the question of legal ownership and authority over management of objects arises. In the case of a museum, it is difficult to imagine a real sharing of ownership, given that the art always remains in the museum and the authority over it is centralized [27]. Blockchain technology could be a partial solution to this problem. Liddell [15] establishes that by sharing ownership, museums distribute power over the object and in this

way, participants become like stakeholders. In order for them to really feel like shareholders, having a material claim would help. Tokens like NFTs could be that material claim, which would be a proof of shared guardianship or ownership and would represent the stakeholder's authority over the museum object.

F. Smart museum

Heritage institutions require certain conditions for the preservation of their materials, such as a certain level of humidity, temperature, security system, etc. To facilitate the monitoring and maintenance of favorable conditions, the Internet of Things (IoT) can be used in combination with the blockchain. IoT represents the connection of smart devices via the Internet and the creation of their network. It provides access to data in real time, collects information about the current state of the building and users, enables collaboration, faster decision-making process, detects critical problems and predicts behaviors or failures. The blockchain, on the other hand, ensures data security and is introduced as a system for monitoring, gathering information about the activity of sensors and systems, and for monitoring the activities of people participating in the process. This approach would prevent unauthorized access to data and would ensure their safe storage and management in real time [28].

G. Making profit

With the rise in popularity of NFTs, many museums saw an opportunity to make money and at least partially recover the revenue they lost due to pandemic closures. So, some of them started digitizing their artworks and sell them as NFTs. Among them were the British Museum, the Uffizi Gallery, the Hermitage, the Whitworth Gallery, the Leopold Museum, etc.

The Leopold Museum in Vienna, for example, made a collection of 24 NFTs of the works of Egon Schiele upon the discovery of one of his long-lost works. They used the money from the sale for the conservation of these works and the restoration of the lost painting [29]. This practice could thereby help heritage institutions, not only museums, to generate income for the restoration and conservation of objects through the sale of NFTs [30].

However, although some of the larger museums have generated significant revenues from such sales, research has shown that only a small number of museums are involved, and only 5% of them generated revenues greater than \$250,000 [31]. More and more museums are withdrawing from the sale of NFTs due to the decline of the NFT and cryptocurrency market. Therefore, the use of NFTs for the purpose of providing additional value to visitors has a much greater potential than concentrating only on making a profit.

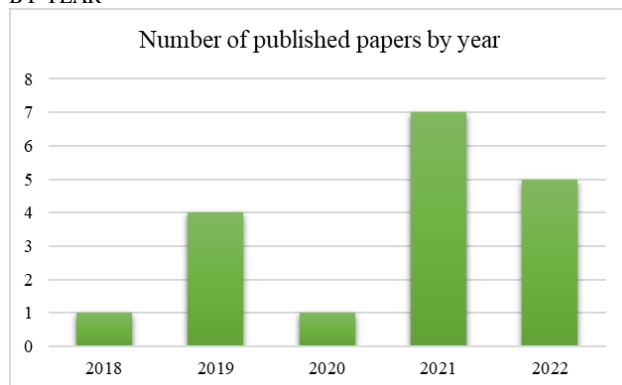
Apart from the profit itself, museums could use the sale of NFTs as an opportunity to attract audiences and reward loyal visitors and customers. Using a smart

contract, the NFT owner could have rights to certain utilities such as museum tickets, a discount on the museum shop or the possibility to participate in the conservation of the museum fund, as was the case in the Leopold Museum. By doing this, museums would improve the connection with visitors, which was already discussed in the chapter on shared ownership and guardianship.

III. DISCUSSION

Papers published so far on the use of blockchain technology and NFTs in the museum environment represent only the beginning of research on this topic. Unlike for example, the archives that began exploring this topic as early as 2016, the first research on application in museums began only in 2018. Covid-19 pandemic and sudden popularity of NFTs have certainly encouraged new research, which is evident from the number of papers published on the topic in 2021 (GRAPH 1). Experts have seen the opportunity in a new technology to solve the problems that museums have faced in terms of content digitization, but also to resolve and simplify some other museum practices such as loan of museum objects or long-term storage of documentation.

GRAPH 1 NUMBER OF PUBLISHED PAPERS ON THE TOPIC OF BLOCKCHAIN TECHNOLOGY AND NFT IN A MUSEUM FIELD BY YEAR



So far, research is mostly based on the potential use of this technology, and only two studies have been conducted in practice and four concrete models for digital rights management have been designed. Further research is needed to better understand blockchain technology and its benefits for the museum sector.

It should be investigated how it is most efficient to connect physical museum objects and their data on the chain, as well as what are the long-term ways of preserving NFTs that become part of museum documentation or collection. Also, it is important to explore the values that NFTs could bring to museums and their audiences, along the lines of social value, which Liddell [15], [26] writes about. Can museums use NFTs and blockchain technology to deepen connections with audiences and achieve greater engagement? Further audience research should answer the question.

Another unaddressed topic in previous research is museum communication through NFTs. Due to the Covid-19 pandemic and the rise in popularity of NFTs, some museums have started experimenting with the new medium and organizing exhibitions dedicated to the new technology, both physically in the museum and in the metaverse. It would therefore be interesting to investigate how the new medium affects museum communication, curatorial practices, and audience experiences in the new environment of the virtual world.

A major obstacle in the implementation of blockchain technology in heritage institutions, including museums, is the lack of knowledge. In most cases, museum experts are not familiar with new technology and the possibilities it provides. It would certainly be useful to do research and create strategies for the education of experts regarding new technologies and their implementation in the museum space. This problem will certainly become less significant over time with the arrival of a new generation of experts who will not be strangers to new technologies, but rather use it as the main tool in their private and professional lives.

IV. CONCLUSION

Blockchain technology and non-fungible tokens have entered a wide social, economic, artistic and many other spheres of life in the last few years. Although it is not a new technology, recently there has been a growing interest in its use. Thus, heritage institutions such as museums, archives and libraries began to explore its benefits. Research conducted so far propose the use of NFTs and blockchain technology in heritage institutions to determine the ownership, authorship, authenticity, and provenance of works of art and documents. Furthermore, they can be used to monitor the loan of objects between institutions, create a register of cultural assets, share ownership of museum objects, etc. Until now, there are several platforms and projects that deal with the mentioned aspects and try to find the best solution for merging new technologies and institutions. Although there are undoubted benefits of using technology, there are also some negative factors associated with it, such as high energy consumption. Also, additional costs for fees, loss of the private key and the risk of incorrectly entered information on the distributed ledger are highlighted.

Many museums saw the sale of NFTs an opportunity to compensate for lost income in the last few years and the possibility of collecting funds for the conservation of museum objects. However, only small number of them made considerable profit. Therefore, museums should shift their perspective and ask themselves how they can use this technology to create additional value to their audience. The first step in doing so is education of museum experts on blockchain technology and NFTs, which was one of the aims of this paper. Blockchain technology and non-fungible tokens in the context of museums is a very broad and interesting topic, and many

research questions remain open and provide opportunities for new research.

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