

***Blockchain and Museums: Towards Secure Digitization and
Legal Traceability of Algeria's Tangible Cultural Heritage.***

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Abstract:

Museum objects and old manuscripts are valuable treasures. Theft, destruction, or damage can cause them to be lost forever. Therefore, digitization is an essential solution for preserving these cultural objects. However, traditional technology used to record this data has a significant disadvantage. This is their centralized structure, i.e. the concentration of information in a single point. If this central point collapses (hardware failure, cyber-attack, natural disaster), the entire system becomes unavailable. This exposes the data to the risk of loss or alteration. Distributed structures and blockchain technology in particular offer robust alternatives. Distributing data to several interconnected points ensures greater resilience in consideration of collapse. Furthermore, blockchain ensures data reliability and traceability thanks to encryption mechanisms. In this article, we will explore how this technology can revolutionize the digital preservation of cultural objects in Algeria.

Keywords: Museums; Valuable Objects; Old Manuscripts;
Digitization; Protection; Blockchain; Digital authentication.

الملخص:

تُعدّ مقتنيات المتاحف والمخطوطات القديمة كنوزاً ثمينة، وقد تؤدي السرقة أو التدمير أو التلف إلى ضياعها إلى الأبد. لذا، تُعدّ الرقمنة حلاً أساسياً للحفاظ على هذه المقتنيات الثقافية. ومع ذلك، فإنّ للتقنيات التقليدية المستخدمة في تسجيل هذه البيانات عيباً كبيراً، ألا وهو بنيتها المركزية، أي تركيز المعلومات في نقطة واحدة. فإذا انهارت هذه النقطة المركزية (بسبب عطل في الأجهزة، أو هجوم إلكتروني، أو كارثة طبيعية)، يُصبح النظام بأكمله غير متاح، مما يُعرض البيانات لخطر الفقدان أو التغيير. توفر البنى الموزعة وتقنية سلسلة الكتل الرقمية (بلوك تشين) على وجه الخصوص بدائل قوية. يضمن توزيع البيانات على عدة نقاط مترابطة مرونة أكبر في مواجهة الانهيار. علاوةً على ذلك، تضمن تقنية البلوكشين موثوقية البيانات وإمكانية تتبعها بفضل آليات التشفير. في هذه المقالة، سنوضح كيف يُمكن لهذه التقنية إحداث ثورة في الحفظ الرقمي للمقتنيات الثقافية في الجزائر.

الكلمات المفتاحية: المتاحف؛ القطع الثمينة؛ المخطوطات القديمة؛

الرقمنة؛ الحماية؛ سلسلة الكتل الرقمية؛ التوثيق الرقمي.

Introduction:

Museum, the treasures of humanity unfortunately face permanent problems: Theft and destruction (intentionally or natural) valuable objects. These losses are not limited to physical objects on display or in storage; they also affect ancient manuscripts, true witnesses to our cultural and intellectual history. If these unique documents are not properly stored, their disappearance means irreversible losses for humanity. In this context, the digitization of museum

objects and manuscripts envisions its full importance. This is a strategic solution to ensure protection and access to future generations. Digitization typically uses a central system where users, considered a client, use computers to document physical items like archaeological finds, artworks, manuscripts, or archives, or to scan these materials. The collected data is stored on a central server. This model is an effective way to organize and centralize information, but there is a major error: Data concentration is one point. Data may be lost or altered in the event of a hardware failure or a natural disaster. In March 2021, a fire occurred at the OVHcloud data center in Strasbourg, France. The fire destroyed data center SBG2 and partially damaged SBG1. Although data centers SBG3 and SBG4 were not directly affected by the fire, they were shut down as a safety precaution. This incident caused service disruptions for numerous companies and public services and resulted in permanent data loss for some ("Le Monde", 2021). Even if a secondary backup server is available, it does not guarantee absolute security. For example, if the main server and its backup are in the same location, a disaster could damage both at the same time.

This is where a distributed structure comes into play. This innovative approach relates to the limitations of the central system. In contrast to centralization, where all data is stored in a single location, distributed structures distribute information about several connected servers (called nodes). Each node contains a full or partial copy of the data, making the system more resistant to failures and cyber-attacks. Even if one or more nodes fail or are failing, the other nodes continue to function, ensuring data availability and integrity.

Blockchain is one of the technologies that use this distributed structure. Blockchain was first introduced over 15 years ago with the creation of Bitcoin, and has since revolutionized many sectors thanks to its unique properties: transparency, immutability (inalterability), and decentralization (Vedika and Nagaratna, 2023). When it

comes to preserving museum objects and digitized manuscripts, blockchain not only makes it possible to store data securely in a distributed manner, but also to certify their reliability and traceability. Encryption algorithms provide data integrity by ensuring that any unauthorized modification or deletion is detectable.

This article examines in detail how blockchain technology can change the way digitized cultural objects are protected and shared. We will explore their benefits, as well as concrete examples of applications in the field of heritage preservation.

2. Current Challenges in Protecting Algeria's Cultural Property:

Algeria has a huge material and intangible cultural heritage that unfortunately attracts the attention of malignant people. Artworks by renowned artists and antique items are becoming increasingly targeted by thieves. This situation highlights the greatest challenges in protecting Algerian cultural heritage.

In 2011, the Musée des Beaux-Arts in Algiers was the victim of a hold-up organized by nine thieves who specialize in works of art. According to the Sûreté d'Alger Communications Unit, the gang planned to export all the stolen objects to foreign countries, where customers prepared to pay astronomical sums were waiting for these valuable objects (Sofiane, 2016).

Another tragic example took place in 2019 at the Musée National des Antiquités et Arts Islamiques in Algiers, the oldest museum in Algeria. This historic site was "ransacked", objects stolen, administrative offices set on fire, and official documents destroyed. Although the fire brigade's rapid intervention prevented the fire from spreading, and the police succeeded in recovering a sword dating from the Algerian resistance to the French conquest (first half of the 19th century), this event highlights the vulnerability of cultural institutions to malicious acts (franceinfo Culture, 2019).

In 1996, the 400 kg "Gorgon" mask was stolen from the Annaba Museum. In 2001, a pottery statue representing the body of Emperor Hadrian was stolen from the Timgad Museum (Faiza, 2023).

Besides being stolen or illegally traded, cultural property is also at risk from natural disasters or accidents like fires, floods, or general decay. This is due to the obvious lack of resources that enable museums to ensure optimal preservation of these treasures. As highlighted in the study by (Fatiha and Ammarous, 2021) carried out at the National Library of Algeria and the study carried out at the Kutama Museum - Jijel in (Cherafa and Rebaine, 2024).

The most surprising event for the official corporations of the Algerian cultural sector responsible for protecting rare manuscripts was the 2021 fire, which destroyed the contents of around 2,000 manuscripts from over 400 years ago and preserved in the family library in the city of Adler, south of the country. Another fire followed in early 2023, which broke out in the family library in Ain Saleh city, in the south of the country, destroying almost 1800 manuscripts, books, and historical documents, of which only a small part had been digitized (Mohamed, 2023).

These incidents illustrate many structural issues, particularly the lack of digitalization. Most Algerian historical works, documents, and registrations have not yet been digitalized, making them even more difficult to protect. Meanwhile, traditional methods for managing inventory, such as paper registers and centralized systems, are susceptible to counterfeiting and destruction.

When stolen works are illegally exported, it is extremely difficult to identify and return them. Imagine that artwork stolen from the «Musée des Beaux-Arts» in Algiers is illegally exported to a foreign country. Thanks to an international public blockchain, this work would have been registered beforehand with indelible information, such as its provenance, detailed description, and unique identifier. When

the work appears in the international market, the authorities will be able to quickly check its origins and prove that had been stolen. This simplifies the legal process for his return. Therefore, it is important to move proactively, especially through the use of modern technologies such as digitization and blockchain.

3. Blockchain:

3.1. Definition:

Blockchain is an innovative technology that enables data to be stored and transmitted in a secure, transparent, and tamper-proof way, without intervention by a trusted third or central authority. Think of it as a large digital ledger that is shared among multiple participants. Here, all information is recorded in connected blocks to form a chain (Bashir, 2018).

This technology became famous in 2008 with the creation of Bitcoin by Satoshi Nakamoto (Nakamoto, 2008). The blockchain was developed after the 2007 financial crisis. This is a special form of distributed ledger technology (DLT) for recording banks in a currency called Bitcoin. Since then, it has been developed for use in many fields, including tangible cultural property protection, copyright and even legal contracts.

In contrast to traditional systems in which a single organization controls data, blockchains are based on distributed networks. This means that each participant in the blockchain network has an identical copy of the register, ensuring reliability and resistance to the operation (Bashir, 2018, p.12-13).

3.2. Blockchain Process:

The blockchain can be compared to a large digital register, protected and accessible to all, where information is recorded in a secure and tamper-proof manner. This register is organized in the form of "blocks" connected to form a continuous chain, hence the name "blockchain".

Each block contains several elements: specific data (the data to be protected), an exact date, a unique digital

fingerprint (called a "hash"), and a reference to the previous block. This structure ensures that any attempt to modify information within a block would be immediately detected. This is because all the following blocks need to be changed. In other words, the blockchain makes it extremely difficult to forge or modify data.

In contrast to traditional systems where a central authority (e.g. bank, institution, or notary) manages and validates the information, the blockchain is based on a decentralized network of participants called "nodes". These nodes work together to verify the authenticity of the data and keep the register up to date. This absence of a central authority improves security and reduces the risk of data manipulation and corruption. To protect information, blockchain uses advanced encryption technology. Each user has a personal "secret code" (called a private key) for the digitally signed data they want to protect. Alongside this, a "public key" (visible to everyone) is used to check the reliability (origin) of the data without compromising its confidentiality. Thanks to these mechanisms, only authorized people can access and modify information.

Another important aspect of blockchain is the data validation process, known as "consensus". To add data to the blockchain, network participants must agree on its accuracy. For example, in the case of Bitcoin, some nodes called `miners` use their computing power to solve encryption puzzles to validate a new block of transactions. This process ensures that all copies of the register remain synchronized and reliable. A key feature of the blockchain is its transparency. All recorded data is accessible to all participants, which creates a high level of trust.

Finally, once data has been added to the blockchain, it becomes immutable: it can no longer be modified or deleted. This immutability ensures the integrity and permanence of the information, which is particularly useful for preserving

cultural documents, works of art, or historical archives (Bashir, 2018).

3.3. Types of blockchain:

There are three main types of blockchain, each adapted to specific needs (Bashir, 2018, p.32):

- 1) Public blockchain: Completely decentralized and open to everyone. Anyone can join the network and consult and validate the data. Example: Bitcoin, Ethereum.
- 2) Private blockchain: Centralised and limited to a specific group of participants. Only authorized people can access or validate data. Often used by organizations or companies for internal projects.
- 3) Consortium blockchain: A compromise between the two above. It is managed by a group of organizations that share responsibility for maintenance and governance. Perfect for sectors where several stakeholders must collaborate, such as banks and healthcare.

3.4. Smart Contracts:

In the legal field, blockchain provides the opportunity to associate recorded data with a particular type of contract known as a "smart contract". This is a self-executed computer program that automates agreements between parties without human intervention. Known by various names such as automatic contracts, autonomous contracts, contract contracts, and distributed contracts, intelligent contracts represent important innovations in the field of digital data.

Traditional legal contracts are defined as formal agreements that define the legal obligations between two parties. This is based on contractual relationship principles, such as offers, acceptance, examination, and desire to develop legal relationships. Terms of the contract are usually negotiated between the parties, agreed by the parties themselves, and may be interpreted and implemented by applicable laws and regulations (Éric, 2017).

In contrast to traditional contracts, smart contracts have the ability to execute the terms of a contract automatically,

without the need for human intervention. This automation accelerates and protects data and reduces the risk of errors and operations. Smart contracts run automatically as soon as the predefined conditions are met. This feature eliminates the delays and inefficiencies associated with traditional contracting processes and ensures the prompt and accurate implementation of agreed terms (zerrouk, 2023)

However, it should be noted that the legal recognition of these terms may vary according to the regulations in force in different jurisdictions. In the legal field, smart contracts can be used to automatically trigger legal proceedings when certain predefined conditions are met. For example, if a party fails to meet its contractual obligations, the smart contract can initiate legal action by notifying (sending an email) the parties concerned or by assigning the necessary evidence to a court. It also simplifies conflict management by ensuring the traceability of violations and providing constant evidence thanks to blockchain.

Technically speaking, blockchain is not a radical innovation, as it is based on proven technology that has been used for a long time, such as data storage using algorithms, peer-to-peer sharing, hashing techniques, encryption (public and private keys), and smart contracts. What is revolutionary is how these technologies are combined to create new functionalities. This synergy is based on a decentralized and distributed system, where trust between users is the cornerstone. In particular, the ability to replicate digital files identically emphasizes the need to ensure the reliability and safety of online data (Deleuze, 2019).

4. Blockchain as an Innovative Technology:

Blockchain technology has attracted growing interest in recent years thanks to its innovative applications in a variety of fields. Originally developed to secure transactions, this technology is particularly well -suitable for preserving cultural objects such as museum paintings, old manuscripts, and artifacts.

4.1. Key Features of Blockchain:

Blockchain has many features that respond to the current challenges of preserving tangible cultural property (Bashir, 2018, p.24-25):

- 1) Increased security: Thanks to its decentralized structure and the use of advanced encryption technology, blockchain is highly resistant to cyber-attacks. Each object or manuscript recorded on the blockchain benefits from enhanced protection against falsification and unauthorized access.
- 2) Total transparency: All information about objects - their origins, origins, movements between museums or private collections - are recorded on the blockchain and accessible to all authorized participants. This transparency means that the history of a cultural object can be followed precisely, making it easier to track in the case of theft or dispute.
- 3) Eliminate the intermediary: blockchain eliminates the need for traditional, trustworthy third parties, such as notaries or experts. Data can be verified directly by all involved parties thanks to algorithms, which reduces administrative costs and time.
- 4) Data Immutability: Once data is recorded on the blockchain, it cannot be modified or deleted. This immutability guarantees the integrity of the data and provides undeniable evidence of reliability and the origins of cultural property.
- 5) Proof of existence: Blockchain can be used to certify the existence of an object at a particular time. This is especially useful in proofing the credibility of old paintings and manuscripts in the event of legal disputes or international claims.
- 6) Decentralized: In contrast to centralized systems, where data is stored on a single server that is vulnerable to breakdowns or attacks, blockchain is based on a distributed network. This significantly reduces the risk of data loss and ensures that the information is more durable. Each

participant in the network has an identical copy of data, improving security and reliability.

- 7) Anonymity: User's identities are protected by encrypted addresses, ensuring confidentiality and data transparency.

4.2. Example of a Real Application:

Musée D'Orsay used blockchain to protect and authenticate digital artwork. The initiative includes the "Le Code d'Orsay" exhibition and the creation of digital souvenirs related to the Van Gogh exhibition, all recorded on the Tezos blockchain. This technology guarantees the authenticity and traceability of works, offering an innovative solution to counterfeiting risks (Julien, 2024).

Auction houses are also adopting this technology, with startups such as ArtTracktive (Deloitte Luxembourg), Artory, Codex, and Verisart offering blockchain authentication solutions. In 2018, Christie's made history by organizing the first auction recorded on a blockchain, in partnership with Artory. The Barney A. Ebsworth collection "An American Place," including paintings by Jackson Pollock and Edward Hopper, was immortalized in a transparent and tamper-proof manner (Florian, 2022).

5. Blockchain Process for Protecting Cultural Property:

Blockchain provides a robust solution for the protection of digitized works (objects, paintings, manuscripts, documents, archives) held in museums. This technology can be used to ensure the security, traceability, and management of the rights associated with these tasks:

1) Initial registration of Works on the Blockchain:

When a work is digitized, it is immediately registered on a public, private, or consortium blockchain. This record includes important information such as the identity of the owner or the institution (museum), a detailed description of the work, an accurate timestamp, and a unique digital fingerprint generated by a hash function.

This data is grouped in a block which becomes an integral part of the chain, ensuring its authenticity and

immutability. For example, a painting in a museum could have a digital certificate on the blockchain. This certificate would verify the painting's origin and history.

2) Data security using encryption:

The security of digitized work is improved through advanced encryption technology. Each user (for example, the museum curator or the artist) has a pair of encryption keys: a private key to sign the data and a public key to verify its authenticity.

3) Validation:

Recordings of works, including work details and digital signatures, are stored on a block. Before adding the new block to the chain, a crucial mechanism comes into play: consensus. This process requires network nodes to agree on the validity of the data. Without this system, there would be nothing to prevent a malicious actor from inserting false information. Consensus thus ensures that each added block is approved transparently and securely, reinforcing trust in the entire system.

4) Traceability and transparency:

Blockchain technology ensures transparent and immutable record keeping of all modifications and movements pertaining to an artwork. This enables : Comprehensive provenance tracking, documenting the artwork's complete history from creation through exhibitions and institutional transfers; Rapid identification of stolen or counterfeit works by cross-referencing their unique identifiers with blockchain-stored data; and Streamlined restitution processes in cases of theft or international dispersal, as verifiable proof of ownership and provenance is readily available. For example, if an old manuscript is stolen and is illegally sold overseas, its presence on the blockchain would allow the authorities to prove its origin and get it back.

5) Using Smart Contracts for Rights Management:

Smart contracts can play an important role in managing the rights related to cultural objects. For example, when a

museum wishes to lend an artifact to another institution, the terms of the loan (duration, conservation conditions, financial compensation) can be codified in a smart contract. Once these conditions have been met - such as payment of the agreed compensation - the contract is executed automatically, guaranteeing a transparent procedure with no intermediaries. This automation reduces administrative costs and time while minimizing the risk of error or fraud. Furthermore, since the contract is stored on a blockchain, it cannot be modified or deleted, offering a high level of security and trust.

6. The Potential of Blockchain for the Heritage of Algerian Museums:

By combining decentralization, transparency, and immutability, blockchain offers great advantages in the protection and sustainable management of the global cultural heritage. The key roles in solving these problems are as follows:

- 1) Registration of objects: Each object exhibited in an Algerian museum could be registered on an international public blockchain, with detailed information about its origin, provenance, and history. This would facilitate the identification of stolen works and their restitution.
- 2) International cooperation: A blockchain shared among several countries will allow for coordinating efforts to restore decentralized tangible cultural property. For example, a painting stolen in Algeria could be identified and returned thanks to its unique registration on the blockchain.
- 3) Protect from natural destruction: In the case of natural or accidental disasters (such as fires or floods), the digitized data on the blockchain will ensure that information about objects is permanently stored.
- 4) Complementary to traditional methods: Blockchain offers significant advantages, but does not replace traditional methods for protecting tangible cultural

property. On the contrary, it complements them by providing solid and undeniable digital evidence. For example, certificates of authenticity issued by experts can be protected by blockchain data records and create a double layer of protection.

Furthermore, blockchain can accelerate legal process in the event of theft or legal dispute. Instead of relying on paper documents and experts to authenticate objects, authorities can rely on immutable data recorded on the blockchain. This does not mean that traditional methods will be abandoned, but they are enhanced by this technology.

7. Professional Opportunities:

The integration of blockchain and related technologies, such as smart contracts, in the cultural sector opens up new professional opportunities and redefines the skills required of those involved in cultural heritage. This transformation will impact lawyers, museum professionals, and cultural institutions, creating a dynamic ecosystem in which traditional professions are evolving into more technological and specialized roles. New hybrid professions such as "Heritage Data Manager", "Digital Curator" or "Cultural blockchain specialist" will emerge. These professionals will be responsible for monitoring the recording, securing, and management of cultural objects on the blockchain while ensuring their physical preservation. The combination of legal expertise, technical skills, and cultural know-how will help the sector provide fertile ground for innovation through the creation of a center for experts. These centers serve as innovation platforms, where professionals experiment with new approaches to preserving and promoting cultural heritage.

Although blockchain is a revolutionary technology, it raises many complex legal issues. This has led to the emergence of law specializing in this field, capable of responding to the specific challenges associated with this innovation. These companies provide services tailored to the

needs of cultural institutions. The lawyer will assist the museum in registering objects on the blockchain and ensure that all information complies with applicable regulations. For example, they ensure that recorded data meets confidentiality and data protection standards. This registration includes the certification of authenticity, traceability, and the protection of intellectual property rights. In cases of theft, forgery, or controversial property, lawyers play an important role by using the immutable evidence provided by blockchain. They can also intervene across borders in conflicts, facilitating the restitution of works thanks to the data recorded on the blockchain (Othman, 2023).

There are currently law firms specializing in new technology law, including smart contracts, such as Hashtag Avocats (<https://hashtagavocats.com>). This law firm assists startups and companies in the field of new technologies, including intellectual property and smart contracts. They offer legal advice on securing digital projects and copyrights. Another firm is Murielle Cahen (<https://www.murielle-cahen.fr/le-cabinet-murielle-isabelle-cahen-avocate/>). This firm is exploring the legal implications of smart contracts and could offer services related to their use in the context of copyright and the preservation of cultural heritage.

Conclusion:

Algeria's tangible cultural heritage faces constant threats, ranging from organized theft to catastrophic fires. Stolen objects disappear onto the global black market, and undigitized collections are reduced to ashes. Traditional heritage preservation methods are no longer sufficient.

Protecting tangible cultural property in Algeria and around the world requires tools that are up to modern threats. In this article, we presented the potential of blockchain technology for the protection of cultural heritage in museums. We explained its properties of transparency, immutability, and decentralization, thus enabling optimal data security for tangible cultural property, facilitating its restitution, and

strengthening its legal protection. Blockchain allows authorities to trace stolen objects beyond borders and recover them thanks to undeniable evidence. The embedding of blockchain in the cultural sector is more than just a technological adoption; it is profoundly transforming professional practices and career opportunities.

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