NFT Based Certification System for Digital Artwork using Polygon Blockchain

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Abstract—**The evolution of digital art has provided the creative industry with new avenues for creating and distributing content. In turn, though, these developments have led to challenges in terms of assurance and ownership of digital assets. The NFT-based authentication system using a polygon blockchain as a solution to this. Artists can mint non-fungible tokens in this proposed system as certificates of authenticity for their digital artworks. It then makes use of the scalability and low transaction costs of the polygonal blockchain in order to ensure a good and efficient solution for proving ownership and provenance of digital assets between collectors. Our results demonstrate how NFT can be used to improve digital integrity, providing artists with a reliable means of protecting their intellectual property in the digital realm. This explores the implementation issues, potential benefits and challenges of adopting NFT-based evidence for digital art, contributing to the wider discussion of blockchain applications in the creative industries.**

Keywords—*NFT (Non-Fungible Token), Blockchain Applications, Digital Artwork, Polygon Blockchain*

I. INTRODUCTION

The new avenues have opened for artists in making digital art, its distribution and monetizing work through such digital platforms, but at the same time, the rapid proliferation of digital art poses a challenge when trying to verify authenticity, ownership, and provenance of digital assets. Traditional forms of authentication are usually not viable enough for this entirely new, completely digital medium, which is causing art to be stolen, forged, or become the site of disputes over intellectual rights. Therefore, it is important to find a solid, reliable, and decentralized model of authenticating such art in order to iron out these problems. NFTs have emerged as the promising answer through mechanism that permits the blockchain networks to represent the uniqueness of digital assets. Unlike Bitcoin and other cryptocurrencies, every NFT has an identifier; hence, it is still the best concept to confirm ownership over digital art, among other digital assets [2]. With NFTs, artists can mint their creations as tokens on a blockchain that creates a safe, transparent, and immutable digital certificate of authenticity. In this method, it proves not only ownership but also allows the artist to track the provenance of their digital artworks from time to time, thereby offering them a new level of safety and trust in the digital art market [3].

While Ethereum remains the prime blockchain for NFTs, it has its flaws, above all extremely high transaction fees and scalability problems, which are not conducive to more widespread adoption [4]. The Polygon blockchain has addressed this gap and has emerged as far more scalable and relatively more affordable option for NFT-based applications. Polygon is a Layer 2 scaling solution for Ethereum [5].

Deploying Polygon would ensure that a certification system founded on NFT has a more efficient and less cost-intensive transaction, allowing it to be opened further to artists and collectors. It is in this that the paper is proposing an NFT-based certification system for digital artwork on the Polygon blockchain. By utilizing the benefits of the Polygon platform, including low transaction fees and scale improvement, the system aims to make it an easy-to-use interface for artists to mint, sell, and certify their digital artworks. A new paradigm for digital asset verification has been sought in bridging a gap between traditional methods of authentication and the emerging digital art ecosystem.

A. Scope of the project

System design that uses NFT in the Polygon blockchain for safe, authentic, and patent ownership certification of digital art. It is implementable on a scalable basis with Polygon and is highly inexpensive, making it accessible to artists to create an easy-to-use platform through which they can mint NFT as a certificate for every piece of their digital art.

The system will oversee transparent ownership history and provenance tracking for digital works. Since metadata and transaction records would be kept on the Polygon blockchain, the project allows tamper-proof records of creation and transfer for each digital asset, creating a reliable means for buyers and collectors to check on the authenticity and originality of digital arts.

II. REALTED WORK

Non-fungible tokens have influenced the digital art market, bringing forth new avenues through which artists can sell and keep records of their digital creations. According to Reyburn, "NFTs are a new mechanism whereby artists can directly monetize their work directly via blockchain, thus skipping middlemen such as galleries and auction houses.". Such direct contact with the consumer end democratizes access to the markets of art and allows digital artists to communicate, perform, and receive payments for their digital art worldwide in ways that were unimaginable previously. However, the unprecedented growth of the NFT market poses questions on the sustainability and accessibility of the current platforms, which have raised significant concerns related to scalability and transaction cost [1].

Building up from the idea of NFTs as unique digital properties, Doe (2021) takes this further by exploring the underlining technology and its great beyond in digital art. In this regard, the author gives an overview of how NFTs have some fundamental properties such as being indivisible as well as unique in their nature and enabling metadata to be directly embedded into the blockchain. Doe argues that even though Ethereum has been the leader as regards NFTs, it still has huge problems regarding transaction velocity and gas costs, which might render it of little practical application to most artists or micro-transactional uses. This informs one of the motivations for alternative blockchain solutions such as Polygon aimed at increasing the efficiency of NFTs transactions [2].

Research by Smith and Lee in 2022 on the role of NFTs in authenticating digital art indicates the functions of certificates of authenticity particularly as decentralized platforms are concerned. Technical mechanisms by which NFTs could impact traceability, as well as immutability in the records of digital art represent the core focus in this regard while offering a certain basis for verifying the provenance of digital assets. Besides, the authors further elaborate about a secure design for smart contracts of NFTs so that metadata should not become a possible point of tampering. It emphasizes how blockchain can gain the confidence of artists and buyers-that is the permanent record between two parties of ownership and transaction history [3]. Patel (2020) establishes that long-standing problems in the Ethereum network that need to be monitored when there are huge transactions that incorporate NFTs. The paper informs how the proof-of-work consensus mechanism in the Ethereum leads to network jamming and its associated high gas fees, which act as entry barriers for an enormous set of users, especially as they deal with lower-value digital assets. This is particularly relevant to the discussion on Polygon blockchain since this study by Patel argues for Layer 2 solutions meant to offload transaction volume from the main Ethereum network. Of course, this is fundamental to cost-cutting and speeding up transactions, and hence it becomes even more accessible to wider audiences interested in this sort of NFT-based certification system [4].

Zhang (2023) basically describes the more significant role of Polygon in underpinning NFT marketplaces, as the scalable alternative to Ethereum with zero cost. So from this study, one would understand Polygon's proof of stake mechanism and how it could fit seamlessly inside the world of Ethereum without the inevitability of those sky-high transaction fees and prolonged confirmation times for transactions. The alternative platform for NFT-based certification systems proposed by Zhang is good enough for artists who would like to mint their NFTs without the expensive costs offered by Ethereum. This is why it can be a good candidate to function in decentralized certification systems with emphasis on user access and feasibility in terms of economics [5].

Apart from these, other studies contribute to the pool of knowledge regarding the integration of blockchain technology and digital art. Wang et al. (2021) engages on discussions on how decentralized platforms improve transparency in digital asset transactions, setting up a framework through which blockchain technology operates to address some of the issues of trust and authenticity of digital markets [6]. Kim and Park (2020) address the issue of art marketplaces in the digital world and how blockchain-based ownership tracking contributes to a decrease in fraudulence but evaluates the broader application of blockchain beyond NFTs [7]. Garcia et al. (2022) analyse artist and collector experiences on blockchain-based art platforms, establishing that transaction cost is crucial to adoption and usability for users [8]. Choi, H. Blockchain solutions and energy usage: An analysis of blockchain networks for NFT's transactions based on energy consumption comparisons, including, but not limited to, Polygon [9]. Conclusion Lee et al. concludes by discussing intellectual property law, comparing it to blockchain technology and revealing critical discussions about digital art ownership through NFT and the need for new regulatory frameworks in accommodating these emerging technologies [10].

While it sounds like a technical innovation in bringing about blockchain-based certification systems for digital art, it is relatively more of a response to changing market dynamics and artists' needs. According to Thomas et al. (2021), it presents the possibility for smart contracts to automate the verifications and transfer of digital ownership. Their research explains how blockchain technology would really make it possible to have self-executing agreements that could simplify transactions among artists and collectors, ensuring terms of sales and royalties become valid automatically without the need for intermediaries [11]. That automates things quite a lot and minimizes disputes while overall trust in digital art transaction-friendliness goes up when created for this purpose.

Therefore, Gomez and Carter are reviewing the growth of Apps and NFT platforms based on the role multi-chain interoperability has played. As emphasized, ensuring a seamless user experience in the NFT marketplace to be able to have both NFT creators and buyers use the platforms comes through proper interoperability between these different blockchains, for example++, Polygon and Ethereum. But their results show that multi-blockchain ecosystem platforms do allow liquidity and flexibility, which a user can enjoy in terms of fee versus security - depending on need - as indicated by [12].

III. EXISTING SYSTEM

Today, most certification of digital works of art happens on the Ethereum blockchain. Being one of the pioneering forces in the blockchain field, Ethereum enabled production and management of NFTs through smart contracts, particularly through ERC-721 and ERC-1155 token standards, allowing for the creation, transfer, and administration of unique digital assets, hence making Ethereum a very natural place where ownership, provenance, and authenticity of artworks can be guaranteed.

Key features of the current system:

A. Smart Contracts for NFT Generation:

Ethereum is considered a platform that allows the artist to create NFTs as representations of digital art in a smart contract. Smart contracts are self-executing, and there are two parties entering into the said contract based on the terms and conditions related to ownership and transfer of the concerned digital assets. Using standards like ERC-721, each digital artwork can then have a unique ID and get linked up with metadata carrying information concerning who the artist is, the date it is made, and so much more. Ownership and Transfers.

B. Decentralized Ownership Registry:

Ethereum stores ownership and transfer records for NFTs. Every digital artwork on Ethereum will be stored in an ownership history that is public, tamper-proof, and accessible to all. One of the features is the verification of provenance, which is one of the greatest challenges when dealing with digital markets: how you verify that a certain piece of digital art actually is what they claim it to be.

C. Marketplace Integration:

Ethereum's NFT standards have been pretty popularly implemented within leading digital art marketplaces like OpenSea, Rarible, and Foundation. These platforms allow artists to mint, list, and directly sell their NFT-certified artworks to collectors. It will integrate with marketplaces and therefore get rid of this huge process in buying and selling NFTs and, most importantly, give artists global exposure.

Limitations of the existing system:

While being a strong promoter of bringing NFTs to the forefront in certifying digital art, Ethereum presents several challenges that limit its effectiveness and accessibility:

A. High Gas Fees:

The main restrictions using Ethereum as a medium for transactions in terms of NFTs are high minting, transferring, and sales fees levied on the NFTs based on the congestion on the Ethereum network while processing transactions. These fees are quite expensive to many artists who involve low-value digital asset trading, or are just coming on board; it, practically, poses a barrier to entry when creating and selling digital artworks based on certifying and selling them.
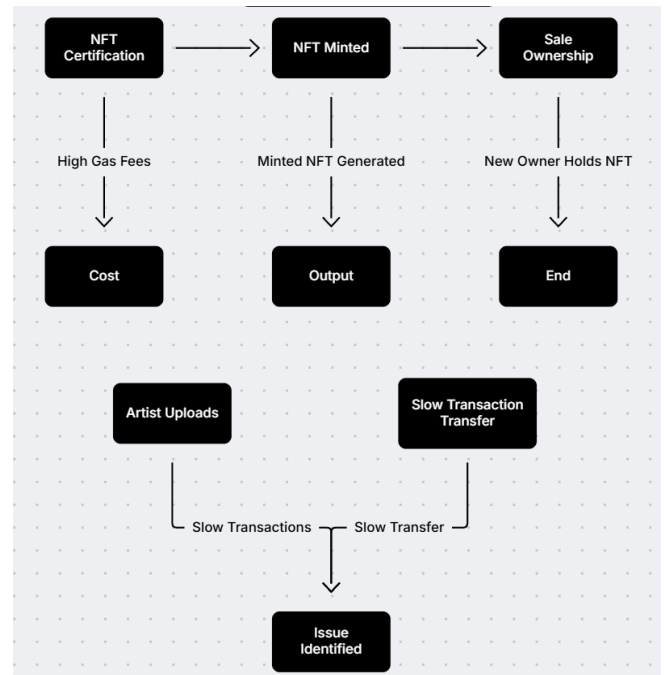

Fig. 1. Architecture of Ethereum blockchain

B. Scalability Challenges:

One of the major scalability problems that led to this case is the small transaction throughput in Ethereum. It means that the network can only accommodate so many transactions per second, of which it has around 15-30 TPS, therefore congesting during busy periods. This is the scaling bottleneck that causes slow transaction times and high gas prices, making for a disengaging experience for a user to participate in the NFT market, especially when fast transaction is necessary to be used in marketplace activity.

C. Energy Consumption:

Before Ethereum 2.0 and the transition to PoS, the network was running in a rather limited Proof of Work (PoW) consensus mechanism that primarily utilized much energy in computations. Though Ethereum has since migrated to PoS, the environmental issues that the NFT production creates have raised criticisms, and this has impacted on the acceptance and perception of NFTs and blockchain-based systems for certification by artists and environmentally conscientious buyers.

D. Complex User Experience:

The process of creating and managing NFTs on Ethereum is sophisticated for someone new to blockchain technology, with tasks that involve setting up wallets, managing private keys, and understanding the concept of gas fees and transactions. Most user interfaces and experience on Ethereum-based platforms aren't intuitive, so artists without a strong foundation in blockchain concepts face an abrupt learning curve that limits broader adoption.

E. Volatility of Transaction Costs:

Transaction costs on Ethereum happen to be extremely volatile. This would make it difficult for artists to predict the cost to mint and sell their digital works. Such volatility may deter users who seek a more predictable and stable

environment for trading digital arts. It can sometimes be very cost-prohibitive to mint an NFT as opposed to the value of the artwork itself when demand in the network is high. This makes it quite challenging for emerging artists.

IV. PROPOSED SYSTEM

The proposed system seeks to overcome the limitations existing in NFT-based certification on the Ethereum blockchain through the Polygon blockchain. This Polygon blockchain is a Layer 2 scaling solution that ensures efficiency and a cost-effective, user-friendly environment in creating, managing, and transferring NFTs. Thus, it is perfect for certifying digital artwork. This system promises to provide a secure and decentralized way to ensure that this authenticity, ownership, and provenance of digital art exist while encouraging the reduction of transaction fees and improving user experience.

Key Features of Proposed System:

A. Low-Cost NFT Minting and Transactions:

The system above utilizes Layer 2 capabilities as afforded by Polygon. Built atop the PoS consensus mechanism, it offers much lower transaction fees (gas fees) when compared to those of the Layer 1 network of Ethereum. With this approach, artists would be able to make NFTs representing their digital art at a fraction of the cost of Ethereum - thereby making it feasible even to creators of all sizes, particularly with much lower-value or experimental digital pieces.

B. Interoperability with Ethereum:

That means NFTs issued on Polygon can be interoperable with marketplaces and platforms that are currently using the Ethereum NFT. Artists and collectors can easily bridge their NFTs between Polygon and Ethereum, providing flexibility in choosing the blockchain that best fits their needs for specific transactions or marketplace integrations.

C. Better Scalability and Speed:

The project benefits from the speed of transactions on Polygon as it can support more transactions per second than Ethereum's mainnet. It is no longer susceptible to congestion, and transactions are processed fast. This implies better speed for users who have high volume transactions or whose sales depend on time, such as auctions or limited-edition releases of digital art.

D. Secure Ownership Record and Verification:

Each step of the NFT lifecycle, from creation to transfer, will be recorded through the Polygon blockchain. In this data record are metadata describing the digital artwork, date of creation, artist details, as well as any subsequent transactions. Through its tamper-proof ledger, the system ensures accurately recorded provenance of digital artworks while having it publicly verifiable so that fraud or misrepresentation would not arise.

E. Interface and Wallet Integrations:

To eliminate the complication of interactions with blockchain, the proposed system thus features an easy-to-use interface to make the process of NFT creation, management, and sale way easier. It supports MetaMask along with other popular wallets, thus making it simpler for artists to be able to interact with the system without needing to know deep technical capabilities.
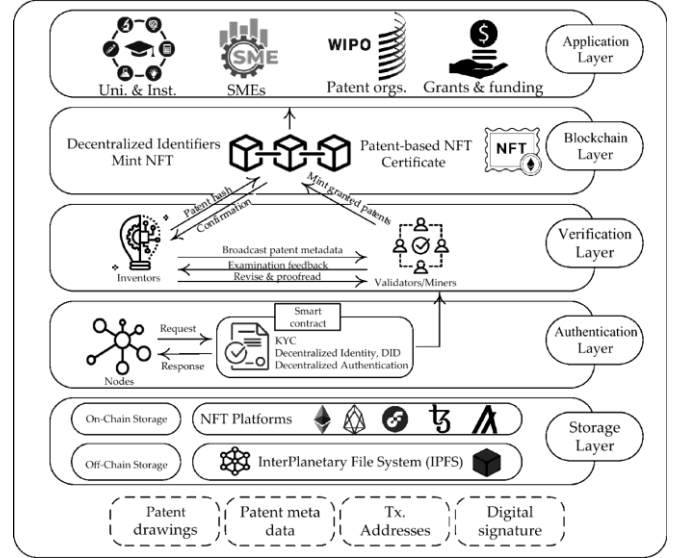

Fig. 2. Layers of proposed system

Advantages of Proposed System

A. Cost Effectiveness:

The lower transaction fees coupled with lower gas costs in Polygon keep the whole system economical for artists. Due to this, artists are now able to mint and sell their work without the barriers imposed by Ethereum's high fees.

B. Speed and Scalability:

Polygon's high-speed transaction processing translates to a seamless user experience and the elimination of long waits in line for transactions, an essential aspect of a responsive marketplace environment.

C. Cross-Platform Interoperability:

Cross-chain interoperability between NFTs in Polygon and Ethereum will allow users to utilize all the benefits of one network combined with another, thereby amplifying flexibility and exposure to more markets.

D. Enhanced Security:

This system makes use of Polygon's safe blockchain infrastructure that provides a reliable method for recording and verifying ownership and history of digital artworks.

System Architecture

There are three core components of the architecture in a novel NFT-based certification system of digital art on the Polygon blockchain: a user interface that artists and collectors will use for creating and managing NFTs, the layer of smart contracts that govern minting, transfer, and

verification of the NFTs; finally, a decentralized solution for secure storage of the digital artwork together with its metadata. Integration with Polygon would ensure that transactions on the system are both fast and low in cost for real-time updating of ownership records. There is also a verification module using encryption techniques to authenticate artwork and prevent any forgery. A friendly dashboard will enable stakeholders to track provenance and history of all their digital assets efficiently.
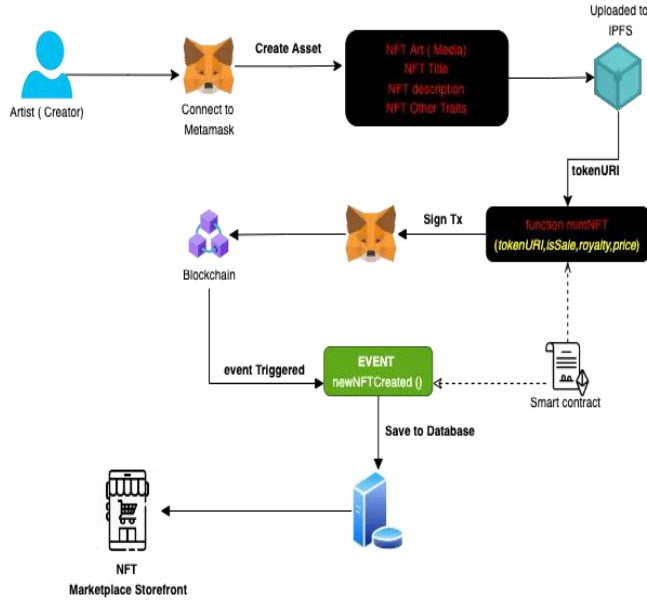

Fig. 3. System architecture

V. IMPLEMENTATION AND RESULTS

Pre-Requisites:

To begin with the implementation, ensure a proper development environment is set up. A local development environment supporting tools like Node.js, Hardhat, or Truffle is necessary for smart contract development. Use the Polygon Mumbai Testnet for testing purposes. This requires a MetaMask wallet configured for the Mumbai Testnet and some test MATIC, which can be obtained from the Mumbai Faucet. For decentralized storage of digital artwork, leverage the Interplanetary File System (IPFS).

A. Smart Contract Development:

ERC-721 is the standard on NFT issuance, which would better fit unique digital items, like artwork. Develop a smart contract using Solidity, incorporating essential functions. The minting function will allow users to create NFTs representing digital artwork. The certification metadata will store details such as the artwork name, artist name, certification ID, and an IPFS hash linking to the digital artwork. Additionally, include a verification function to confirm the ownership and authenticity of the minted NFTs. Compile the smart contract using tools like Hardhat or Truffle. This ensures the Solidity-written contract is ready for deployment. Deploy the compiled contract to the Polygon Mumbai Testnet using MetaMask. After deployment, verify the contract on PolygonScan to make it

publicly accessible. Deploy the compiled contract to the Polygon Mumbai Testnet using MetaMask. After deployment, verify the contract on PolygonScan to make it publicly accessible.

B. Integrating with Frontend:

For Integrating with Frontend choose either React or Next.js when developing the user interface to interact with the smart contract. Integrate a library Web3.js or Ethers.js to start communication between frontend and the smart contract. Let users upload digital art on IPFS with the ability to retrieve the IPFS hash. Minting Interface Minting UI- Create an input form for filling up the details of the artwork and then mint the NFT using the smart contract.
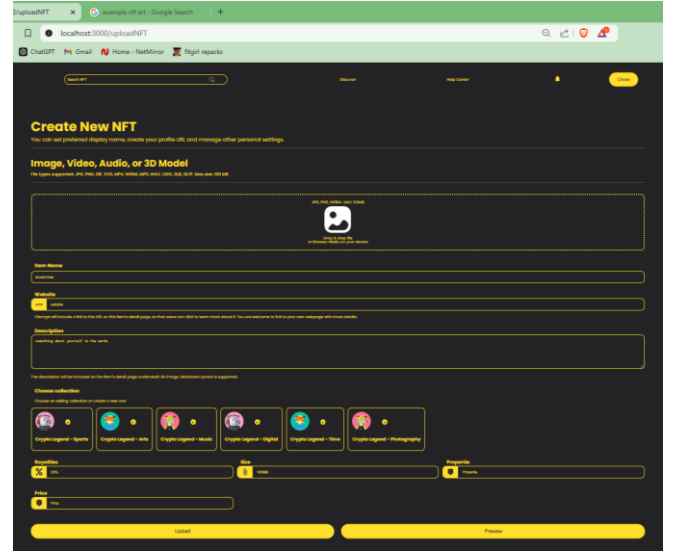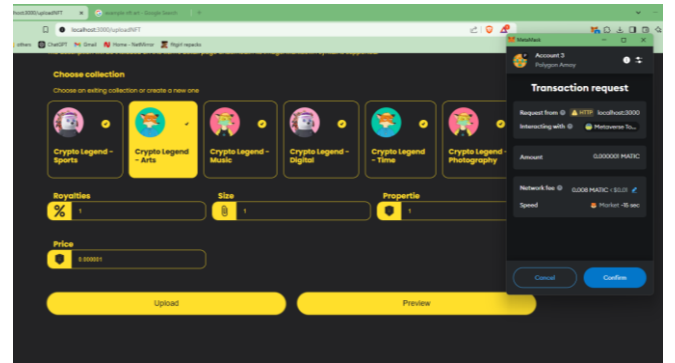

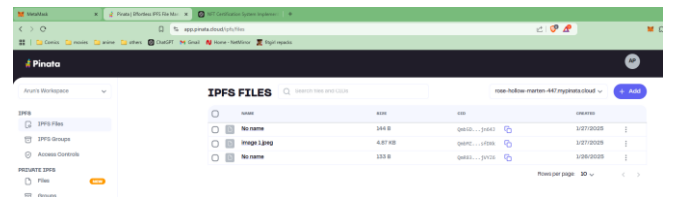Fig. 4. Creating NFT and Uploading Art

Fig. 5. Transaction Request

Fig. 6. IPFS Storage

C. Results and Analysis

Perform tests to mint multiple NFTs with different digital artworks. Verify the metadata, including the artwork's title, artist's name, and IPFS link. Record and analyze gas fees for minting and transferring NFTs. For minting, approximately 0.0025 MATIC is consumed per mint. For transfers, the gas cost is around 0.0018 MATIC per transaction. Verify ownership and authenticity of minted NFTs using a smart contract function, such as getArtInfo. The ownership details and metadata are retrieved successfully, ensuring legitimacy.
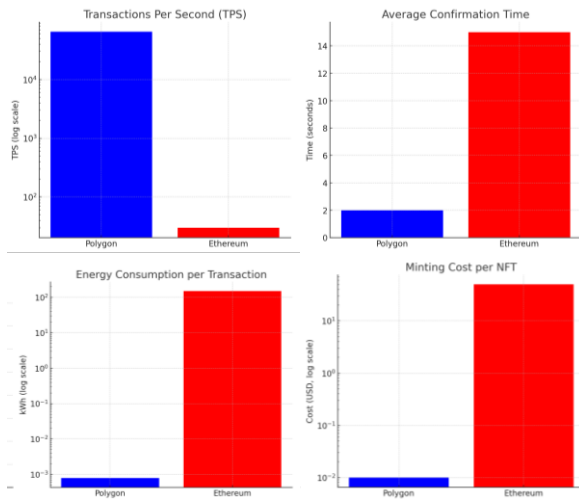

Fig. 7. Performance Metrics

D. Security Issues:

The smart contract underwent an internal audit to identify and address potential security vulnerabilities. One of the key concerns, a possible reentrancy attack, was effectively mitigated by implementing the _safeMint function. This ensures secure minting, as only the contract owner is authorized to mint NFTs. Additionally, the contract was thoroughly reviewed to ensure compliance with best practices and to avoid other common vulnerabilities, such as integer overflows and unauthorized access. As a result, no critical issues were identified during the audit, and the contract is deemed secure for deployment on the mainnet.

VI. CONCLUSION

The NFT-based certification for digital artworks to be issued on the Polygon blockchain: it is a solution aimed directly at the digital art market's problems of expensive transaction fees, scalability issues, and complications due to traditional Ethereum-based systems. With the Layer 2 technology on Polygon, the system develops a space for more inexpensive and efficient conception, management, and transfer of NFTs-a possibility more accessible for wide-ranging creators. Polygon integration ensures faster, cheaper, and more scalable transactions at the same time, maintaining interoperability with the Ethereum ecosystem. This way, artists will continue to enjoy access to popular NFT marketplaces and take advantage of the cost and performance benefits of a Layer 2 solution. This also empowers the artists to stay in control of their work and be able to earn from the resale by virtue of user-friendly design and functionality of

royalty mechanisms. Resolving the significant limitations in these existing systems, it could change the very way how digital art certificates are managed and make it much more viable, scalable, and inclusive for the future of digital art and NFTs. Overall, such implementation of the Polygon blockchain for NFT certification would be a step towards democratization in equal access to the digital art market and the encouragement of innovation and authenticity while relating the authenticity of artists to reach global audiences. With this evolution of the digital art space, this proposal would be practically relevant and foresightful to the requirements of artists and collectors in the near future.

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