Art Market Link: Empowering the Visual Art Industry with a Blockchain-Based Marketplace

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Abstract

Blockchain technology has emerged as a transformative solution with the potential to revolutionize business operations and foster trust in multi-party networks. Its practical applications have found their way into various industries, including the art sector. This paper introduces Art Chain, an innovative trading platform that harnesses the power of blockchain to support and empower the art industry The ArtChain platform encompasses a comprehensive ecosystem, including the front end, back end, services, smart contracts, chain connection, and deployment scripts. As the first deployed blockchain-enabled art trading platform in Australia, ArtChain ensures transparent, privacy-preserving, and tamper-proof transaction records for artwork registration, provenance, and traceability. Through objective evaluation and comparison, we demonstrate the relevance and practicality of ArtChain.

Our paper provides essential insights into the implementation of the ArtChain platform, offering valuable resources for researchers and practitioners in the field. By leveraging blockchain technology, ArtChain introduces a novel approach to art transactions, driving innovation and fostering trust within the art industry.

Keywords *: Brain Machine Interface(BMI), Brain Computer Interface(BCI), Medical Prosthetics, Artificial Intelligence(AI), Mind Reading Technology.*

Introduction

Blockchain, additionally regarded as disb ursed ledger science (DLT) [1], is designed to assist verification-driven transaction offerings inside a usually unreliable ecology. Building trust in an untrustworthy ecosystem is made possible by the intrinsic nature of blockchain technology. Blockchain uses decentralised consensus to ensure that no single party can alter or manipulate the data recorded on the ledger without the consent of other network users. This essential quality ensures the immutability and integrity of stored data. Blockchain technology has numerous enterprise applications, including increasing provenance and traceability in food safety documents [2] and streamlining cross-organizational operations.

With an annual trading value of $200 billion, The art market is a significant sector that operates with minimal regulation, making it prone to various illicit activities, ranking closely behind drugs and weapons in terms of criminal involvement [4]. Within this market, large sums of money are exchanged with limited documentation and transparency. Several critical challenges and issues contribute to these problems, including a lack of transparent expenditure and ownership records (provenance), asymmetry of information leading to limited control over transaction data, difficulties in authenticating and appraising high-value artworks, and a lack of transparency and efficiency in pricing on the primary art market.

The platform's fundamental value proposition rests on four essential elements

Privacy Protection: Leveraging the utilization of a shared ledger, combined with permissioned control, ensures transaction transparency while safeguarding privacy in Harnessing the potential of artwork trading and provenance.

Traceability: Real-time monitoring of individual artworks, integrated The incorporation of the blockchain ledger enhances. in combating counterfeit artworks by facilitating traceability and authentication

Irreversibility: The process of registering collectors By incorporating offline assets onto the blockchain, a permanent and unmodifiable digital record of the artwork is established ensuring accurate ownership, provenance, and valuation.

Transparency: By integrating offline assets into the blockchain, a secure and immutable digital record of the artwork is created.

II. A BLOCKCHAIN APPROACH TO ART TRADING

The rationale for utilizing blockchain technology in an artwork marketplace stems from its ability to address key challenges and provide unique advantages in the art industry. By leveraging blockchain, the art marketplace can benefit from the following advantages:

1. Transparency and Traceability: Blockchain enables transparent and traceable transactions, allowing for the recording and verification of the entire lifecycle of an artwork. Each transaction, including the artwork's creation, ownership transfers, and sales, is securely recorded on the blockchain, providing an auditable and tamper-proof history.

2. Authenticity and Provenance: Blockchain ensures the authenticity and provenance of artworks by creating a permanent record of their origin, ownership, and history. This helps to combat issues related to forgery and counterfeit artworks, providing buyers with

greater confidence in the authenticity of their purchases.

3. Increased Security: Blockchain technology employs robust cryptographic techniques and decentralization to secure transactions and prevent unauthorized modifications. This enhances the security of art transactions, protecting artists and buyers from fraudulent activities and ensuring the integrity of the marketplace.

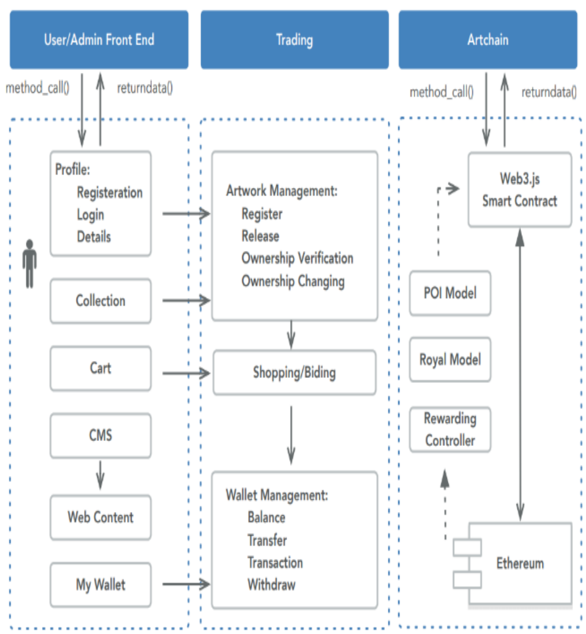

Figure 1. System architecture

4. Efficient and Cost-Effective Transactions: By eliminating intermediaries and facilitating peer-to-peer transactions, blockchain reduces the need for traditional intermediaries, such as galleries or auction houses. This streamlines the buying and selling process, reducing costs and enabling artists to directly connect with buyers.

5. Global Accessibility: Blockchain technology operates on a decentralized network, enabling participants from anywhere in the world to engage in art transactions. This opens up new opportunities for artists to reach a global audience and for buyers to access a diverse range of artworks from different regions.

Gains from a Ethereum-based Art Market

Blockchain technology offers a simplified approach to ensuring the veracity and attribution of artefacts. Provenance, which plays a crucial part of art world, can be verified by utilizing a distributed ledger to track The swap of property rights for time. This decentralized database securely stores essential Particular knowledge about artworks, minimizing concerns about theft or forgery. Consequently, ownership transfers during trading can be conducted swiftly and with undeniable accuracy.

Additionally, blockchain empowers artists to receive royalties from secondary market sales. Legislation passed in 2009 on Resale Payment Options for Fine Workers stipulates a 5% royalty entitlement for artists on specific commercial transactions involving their work.

Blockchain science enables a more successful and public solution to this problem. process for tracking and enforcing royalty payments. Smart contracts, operating on the blockchain, automatically execute royalty transfers to artists when their artworks are resold in the secondary market.

This ensures that artists are duly compensated and contributes to the establishment of a fairer and more sustainable ecosystem that benefits artists

Also, our technique is meticulously designed as an open and scalable infrastructure specifically tailored to meet the unique needs of t The subject matter of art. Its strategic strategy commits that the operation succeeds platform is capable of accommodating future growth and embracing advancements within the art market. It enables seamless integration of emerging technologies, creating expanded opportunities for artists, collectors, and all other stakeholders involved in the vibrant art ecosystem

There is a likelihood that people will be able to develop a wide range of art-related uses for specific scenarios based solely on the ArtChain technology..

3. A OVERVIEW OF THE SYSTEM

Within this section, we begin by presenting the fundamental principles. the structure of the platform, including its high-level components and their significance. We will also present the primary data model diagram and describe the trading system integrated within the platform addition to that, Lets focus on each subject regarding safeguarding and developing faith.

A. Advanced Architectural Design

Then we assessment numerous blockchain architectures to find the best relevant blockchain platform for our project. We chose to use the Proof of a position of authority a consensus approach with the The network private blockchain after taking the business musts and technological concerns into account In the beginning, we thought about using Hyperledger Fabric because of its features, popularity, acceptance, and maturity. The art exchange system intends to combine the payment system and ownership transfer, but it lacked native token support, meaning that is a needed business necessity for our concept. process. To meet the high-performance requirement, we designed and implemented a utility token called ACGT

To leverage the benefits of rapid development and efficient collaboration between multiple organizations, we have adopted a microservices architecture. This architecture offers several advantages, including:

Speedy parallel development: By breaking down the application landscape into smaller, independent microservices, development teams can work simultaneously on different components, enabling faster development and deployment.

Reduced communication time: With microservices, different organizations involved in the development process can focus on their specific components without extensive coordination, leading to reduced communication overhead and faster progress.

Reusable interfaces: When implemented properly, microservices provide clear and standardized interfaces that can be easily reused across different parts of the application, promoting code reusability and interoperability.

Streamlined interfaces: A well-designed microservices architecture minimizes the need for complex handshaking and communication between components, resulting in simpler and more efficient interfaces

Reduced integration and testing time: Microservices allow for independent testing and deployment of individual components, reducing the risk and time associated with integration testing.

Figure 1 illustrates the architecture diagram, showcasing the different microservices and their relationships within the system.

The system architecture is divided into three layers: the user front end, the trading back end, and the ArtChain blockchain layer.

The user front end layer offers a range of functionalities to users, including user registration, login, and profile management. It enables users to browse and manage their artwork collection, handle their shopping cart, access their user wallet, and utilize the Content Management System (CMS) for creating and maintaining web content.

The trading back end layer consists of three core components: Artwork Management, Shopping/Bidding, and Wallet Management. Artwork Management handles tasks related to artwork, such as inventory management, cataloguing, and categorization.

The Shopping/Bidding component facilitates the buying and bidding processes, providing users with a seamless and secure transaction experience. It enables users to place bids and make purchases on the platform.

Wallet Management is responsible for managing user wallets, including tracking balances, maintaining transaction history, and processing payments. It ensures the secure storage and transfer of funds within the platform.

The ArtChain and the blockchain layer serves as the foundational infrastructure of the system, incorporating blockchain technology specifically tailored for ArtChain. It enables the secure recording and tracking of artwork transactions, guaranteeing transparency, immutability, and provenance

Figure 2. Data model: *User* Class

B. Modelling of Data

There are three types of keys of data and objects stored are as follows:

User: This data object contain all the information of user's profile, login credentials, wallet details, and records of auction activities attended. Artists are also considered users with data and verification ,the details of this data object are illustrated in Figure 2.

Artwork: This data object encompasses various details relates to the artwork, including its description, tags, historical records of ownership transfers, and order information. It provided an comprehensive view of the artwork's provenance and transaction history.

Transaction: This data object captures the details of each transaction conducted on the platform. It includes information such buyer, seller, price, date, and any of details pertaining to the specific transaction. This data object ensures transparency and accountability in the art trading process.

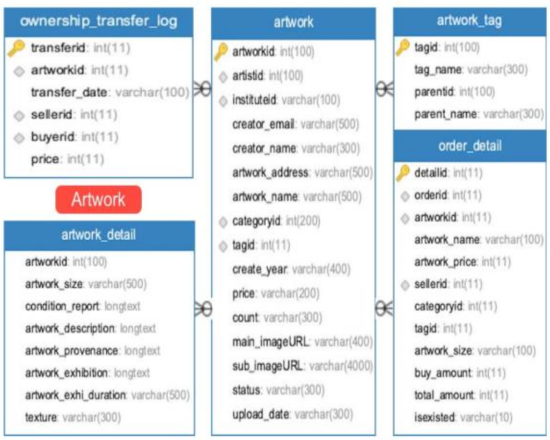

Figure 3. Data model: *Artwork* Class

These groups represent the steps taken to create the masterpiece.. in Figure 3 for a visual representation of the workflow

Figure 4. Data model: *Trading* Class

The Trading component combines the artwork, an order, and the buyer's contact details, including their shipping address. In Figure 4 for an illustration of this process.

The trading system, as depicted in Figure 5, operates as follows: When a user submits a trading request, the profile service , trading Service are triggered to retrieve the user data and trading information. Once the condition of the trading are verified, the Payment Services take on the responsibility of managing the payment transaction. Subsequently, the services of reward are called upon to request and obtain the incentive information. Finally, the shipping service handle the logistics of the shipment to ensure a successful and timely delivery of artwork to the buyer

C. Development of Trust

ArtChain collaborates with renowned and specialized partners in both the primary secondary sectors of art industry includes museums. These partners play a important role in establishing the initial ledger nodes and providing essential services such as validation, ordering, and transaction block generation. By working together with other agent or routing nodes, these ledger nodes ensures security, reliability of block-chain network. Art Chain adopts the Proof-of-Authority (PoA) consensus model, which is particularly suitable for regulated industries where entities take responsibility for maintaining the network. Unlike anonymous mining-based chains, PoA requires trusted authorities to uphold network integrity. Art-chain, esteemed museums and art galleries act as the super-nodes, fulfilling important functions such as authenticity verification and price evaluation for artworks. These super-nodes are responsible to tasks such as validation, block production, and publication within the network..

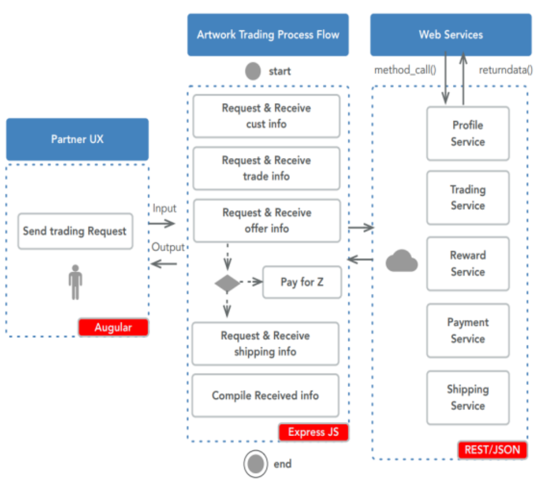

Figure 5. Trading Process

Any node that is attempting to engage malicious activities or becoming a target of an attack that will be promptly detects other nodes in the network once it is exhibited suspicious behaviour, such as sending illegal transactions, launching traffic attacks, or tampering with data. The networks will swiftly isolates the identified node and issue warnings accordingly. Art-chain strategically deployed ledger node across the primary, secondary art markets, includes web company, cloud-service providers, collectors, and artists. This approach minimizes the risk of a majority of nodes falling under attack or colluding to engage in malicious behaviour. By distributing the ledger nodes among various trusted entities,

Art-chain prioritizes the security and integrity of networks by implementing several measures. Initially, 100 nodes are set up to ensure redundancy and protect against a potential 51% attack. While all nodes active simultaneously, they are installed in trusted cloud providers such as AWS and Ali Cloud. The behaviour of these nodes is continuously monitored, it is promptly replaced to maintain network stability.

IV.BLOCKCHAIN IMPLEMENTATION THAT IS SCALEABLE

Here we will present the current implementation of the ArtChain network. We will begin by providing an explanation of tokenization and how it operates within our system. Following that, we will delve into the design implementation of the upgradeable smart contract, which is aimed at enhancing functionality and addressing any issues. Lastly, we discuss our approach to maintaining privacy and confidentiality, ensuring both legal requirements ,business needs

A. Tokenization

Tokenization involves the transformation of asset into digital token on blockchain system, enabling the transfer of the asset ownership through contract. Smart-contracts offer capabilities for automating transactions, implementing algorithms to calculate asset values, and addressing specific feature tokenization goes beyond the mere creations of the token and encompasses the designs of entire system includes the understanding of various rights and concerns. In Art-chain, two types tokens exists : security tokens and utility tokens

The Art-chain network utilizes two type tokens: the ACG2 security token and the ACGT utility token. The ACG token possesses technical characteristics of digital currency including fixed difficulty in unrestricted tradings, protection against double spendings attack, a transparent transactions history. Smart contract implemented in the system. To cater to the needs of corporates and institutional users, we have developed enhanced E-wallets that encompass all the necessary functionalities for interacting with art-chain platform. The ACG token serves as an incentive for maintaining integrity of art-chain network for supporting the overall ecosystems of art-chain application.

• maintenance on a network: The ArtChain community ensures the consistency and stabilities of network through the collaborative efforts of ledger. Ledgers are rewarded with ACG tokens as rewards and transactions fee, serving as an incentive for their active participation in maintaining the security of art-chain network.

Applications of Ecosystem: ArtChain implements a reward system where users are granted newly generated ACG tokens based on specific indicators. These indicators include the frequency of users' interactions with art-chain eco-systems, their level of contribution, impact, and the amount that ACG tokens hold. The eco-systems are quantifiable and verifiable, and their computation is facilitated by the ledger nodes. Under the POI mechanism, incentives are distributed to users based on their engagement with art-chain platform.

A feedback mechanism will be used dynamically change the distribution of incentives for both the upkeep of art-chain community and ecology of art-chain applications. This mechanism make both parts are balanced and stable. Prior to the introduction of important applications, the precise metrics and algorithms employed to calculate the incentive ratios will be made public. These metrics and algorithms will be used in a transparent manner through open contractual rules. Additionally, pertinent institutional users within the ecosystem, including art galleries, museums, auction houses, and artists, will be consulted to gain their insightful feedback.

For facilitating payments in the trading works of art, ACGT is only used on the art-chain platform. It performs the function of a stablecoin, which is one that aims to reduce volatility by maintaining a constant value or price over a set time period. These tokens seek the relative price stability of money while maintaining the values of cryptocurrencies, such as decentralisation and security. every ACGT token is backed by

1 AUD worth of fiat-currencies that the platform holds in an identical amount.

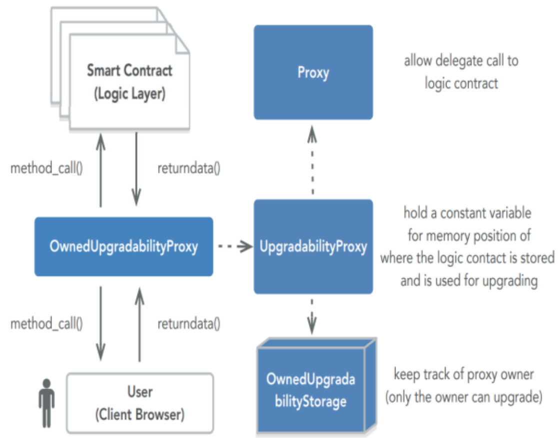

Figure 6. Zepplin proxy architecture pattern

a main custodians. Holders will be guaranteed the right to exchange their token for a certain amount of fiat-currencies at any time.

B . Upgradable smart - contract

After being implemented on blockchain, a smart-contracts are practically unchangeable. A lot of research has been done suggest an upgradeable graph sample of the clever contract in view of malicious programme restoration and characteristic improvement [11]. The standard tactics comprise: • Distinguish between stats and common sense

• Partially upgradeable smart contracts technology

• Sort records and good judgement into key-value pairs.

• Proxy contracts for eternal archiving

The proxy-mechanisms are

the most effective approach out of these.

The Unstructured Storage Pattern, which offers flexibility and enables a fully upgradeable process where the logic can be totally rewritten while keeping the present data state, is implemented using Zeppelin's proxy patterns ,in figure 6 the contract structure is described in detail.

The following characteristics of the system are made possible by using pattern mentioned below:

Why Since most customers are ignorant of contract upgrades, the user experience is seamless.

• The logic contract implementation is completely upgradeable, enabling changes without affecting the current data structure.

• Since data is saved in the proxy contract, data field can be added through the improved logic contract without having an impact on the current data-structures.

C. Initializing Issue

In our application, we have also addressed the challenge of contract initialization, which has long hindered the Ethereum platform. Our main objective is to create logic contract that can be upgraded, and to achieve this, we have devised a proxy that delegates authority to a preexisting deployments of the logic contract on the block-chain, due to this approach, the proxy of contract is unable to perform the necessary initialization operations in the logic contract's constructor. To overcome this limitation, we have to implement initializer functions than relying solely on the constructor. This initializer function allows us to successfully execute the essential initialization step, ensuring it is performed only once.

Furthermore, there are other proposals for contract initialization, like use of Initializer Contracts [13] [14]. Exploring alternative approaches will provide valuable insights and potential solutions to address the challenge of contract initialization in upgradeable system**.**

D. safety oversight

Ensuring transaction security is a top priority within the ArtChain community. To achieve this, ArtChain utilizes various security measures, including blockchain consensus, digital signatures, and encrypted wallets for end-users. These measures are in place to safeguard users' accounts and funds, guaranteeing the authenticity and integrity of transactions.

ArtChain's art trading platform goes above and beyond to provide robust security services that are on par with those offered by established financial institutions. By leveraging the capabilities of blockchain technology, ArtChain seamlessly integrates data, services, and transactions within secure blockchain clouds. This integration encompasses efficient data storage, network resources, and other essential components, resulting in a highly secure transaction environment.

Through the implementation of advanced encryption techniques and decentralized consensus mechanisms, ArtChain ensures that transactions conducted on its platform are resistant to unauthorized access and tampering. Users can trust in the safety of their transactions, enjoying a level of security comparable to that provided by reputable financial institutions

E. Administration of finances:

ArtChain upholds a strong commitment to maintaining integrity . We compliance with suitable laws, regulations, and industry self-regulatory standards. Additionally, we have implemented a comprehensive Know-Your-Customer (KYC) procedure to fulfill our regulatory obligations.

By adhering to these rigorous standards, ArtChain prioritizes the security and trust of its users and stakeholders. We operate with transparency and accountability, seeing that business activity align with legal and regulatory frameworks. Through our KYC process, we aim to verify the identities of our users, promoting a safe and secure environment on the platform

F.Privacy and Confidentiality

To promote transparency, ArtChain allows real-time access to the current state of ledger nodes, ensuring that both state records and transaction records (block content) are publicly visible. However, ArtChain also prioritizes the protection of sensitive data and complies with privacy requirements for specific transactions. Careful consideration is given to the design of the data model, determining which data should be stored on-chain and which should be stored off-chain.

ArtChain's data model is developed in accordance with industry demands and regulatory standards. Presently, on-chain data storage includes crucial information such as artist details, ownership hashes, pricing information, and transaction history. The use of ownership hashes ensures the privacy of individuals who prefer anonymity and adheres to privacy regulations such as the General Data Protection Regulation (GDPR).

Striving for a harmonious balance between transparency and privacy, ArtChain creates a secure and compliant environment for participants. By maintaining transparency, ArtChain fosters accountability and trust within its ecosystem while simultaneously safeguarding the privacy of sensitive information

V. REVIEW OF PERFORMANCE

ArtChain has demonstrated impressive performance during system testing, and it has identified the low-level I/O efficiency of the Ethereum client, particularly Geth4 in its system, as the primary performance bottleneck. To address this limitation, ArtChain has implemented a private chain using the Proof-of-Authority (POA) consensus algorithm, resulting in significant improvements to the overall system performance.

By leveraging a private chain and utilizing 6 cloud nodes equipped with 8x2.5GHz CPUs and 32GB of RAM, ArtChain is capable of supporting a remarkable transaction rate of up to 1500 transactions per second (TPS). This TPS rate far exceeds the capacity of the Ethereum mainnet, which is currently limited to 15 TPS. It's important to note that the TPS measurement provided by ArtChain refers to raw transactions per second.

In practical usage scenarios, ArtChain incorporates various integrated human processes, such as publishing new artwork or obtaining top-up tokens, which often involve multiple chain transactions and queries. Through the application of standard techniques, ArtChain efficiently handles between 40 and 70 such operations per second.

ArtChain's private chain implementation offers substantial performance enhancements and scalability compared to the Ethereum mainnet, ensuring a seamless and efficient user experience. By overcoming the performance limitations and accommodating a higher transaction volume, ArtChain solidifies its position as a reliable and high-performing platform..

A. Settings for the Environment

The private chain deployed by ArtChain consists of three Alibaba Cloud servers, each equipped with 8x2.5GHz CPUs, 32GB of memory, and a 64GB hard disk. Additionally, three AWS cloud servers are utilized, featuring 8x2.5GHz CPUs, 32GB of memory, and an 8GB hard disk. For the implementation, Geth version 1.8.17 is employed, and specific startup parameters are configured to optimize performance.

The startup parameters include:

"--targetgaslimit 4294967295": This expands the gas limit to 0xFFFFFFFF, allowing a higher number of transactions to be included in a single block. It is essential to ensure coordination with the gasLimit value specified in the genesis.json file during the chain creation process.

* txpool.lifetime 24h --txpool.accountslots 65536 --txpool.globalslots 65536 --txpool.accountqueue 64 --txpool.globalqueue 65536 By increasing the transaction pool's capacity, these parameters allow it to hold more transactions both globally and at the account level. Effective transaction handling is ensured by this optimisation.

To interact with the private chain, ArtChain utilizes web3.js, a popular JavaScript library for Ethereum. Additionally, Wireshark, a packet capture and analysis tool, is employed to monitor and evaluate the network traffic and performance of the system.

By carefully configuring the startup parameters and utilizing appropriate tools for performance monitoring, ArtChain aims to optimize the efficiency and reliability of its private chain implementatio

B. Throughput Analysis

The throughput of a blockchain depends on two key factors: the time taken to create a block and the maximum number of transactions that can be included in a block. The theoretical throughput is calculated by dividing the number of transactions by the block interval. However, in large-scale networks, the broadcast speed also plays a role in determining throughput. Ethereum mainnet serves as an example, illustrating how network congestion leads to longer synchronization times and reduced throughput. This enlarging issue is acknowledged within the Ethereum community.

To enhance the efficiency of our private chain, we implemented the following strategies:

We adjusted the block interval in the genesis JSON file to expedite block generation. While a 5-second interval proved acceptable, we discovered that a 1-second interval yielded optimal results.

By increasing gas limit , this adjustment not had a significant impact on performance since the gas limit was not a bottleneck in our system.

Due to our chain being maintained by only six cloud servers, we could mitigate the network scalability challenges mentioned earlier. As lengthy as transactions are successfully executed, there is ample time for node synchronization. The performance of the system is predominantly influenced by the hardware configuration of the nodes. We encountered frequent crashes with the Geth client, known for its memory-intensive nature. Geth follows a "I use up what I have" approach, often consuming all available server memory. Our node servers disable swap by default, and if the Geth process exceeds the permitted memory usage, it is terminated. Unfortunately, this issue persists.

During our tests, we observed that generating 70 new accounts caused Geth to consume 8GB of memory. One suggestion is to enable swap on the node, although it may impact performance. It is mandotary to note that the limited disk capacity of AWS cloud servers restricts the available swap space

C. Testing Results

During the raw transaction test, we configured the chain with a block interval of 5 seconds. The following observations were made:

Each transaction consists of 50 bytes of data, which represents the standard fee for accepted transactions.

Across each node, we could establish approximately 2000 transactions within a time frame of 6-8 seconds.

Furthermore, we conducted 20000 ordinary transaction queries per node, with responses ranging from 2 to 5 seconds in time.

Moving to the API-based test, we focused on different APIs and their performance characteristics:

APIs such as test user(), check transaction(), and test artwork() solely retrieve statistical information from the chain and do not involve practical transactions. Consequently, these APIs demonstrate high throughput similar to regular queries, as their performance relies on the processor and network capabilities.

Conversely, APIs like purchase tokens(), submit new artworks(), and freeze tokens() combine a collection of queries and transactions. These operations often depend on the outcome of preceding actions, resulting in poor parallel performance. For instance, the submit new artwork API encompasses sixteen low-level operations

- 2x eth.sendTransaction
- 1xpersonal.unlockAccount
- 1xeth.estimatesGas
- 2xeth.gasPrice
- 6xeth.getTransactionReceipt
- 2xeth.subscribe
- 2xeth.unsubscribe

Below are the results of the checks conducted:

- The API "post new artworks()" was executed 116 times and took approximately 18-20 seconds per node.
- The API "purchase tokens()" was executed 58 times and took about 5-6 seconds per node.

The API "add new user()" involves a low-level operation called "personal.newAccount," which requires significant memory and CPU resources. The average result is as follows:

- The API "add new user()" was executed 64 times and took around 20 seconds per node.

3) Test on different block intervals:

We conducted tests using block intervals of 1 second, 2 seconds, 5 seconds, and 15 seconds. The comparison of API-based throughput with different block intervals is summarized in Figure 7.

During the test, all APIs were called simultaneously, making sure that all of the transactions was sealed in a single block. Our chain is fully capable of guaranteeing this. Therefore, apart from the difference in block intervals, these calling methods require nearly the same processing time on the network and processes. This is why different block intervals result in different throughputs.

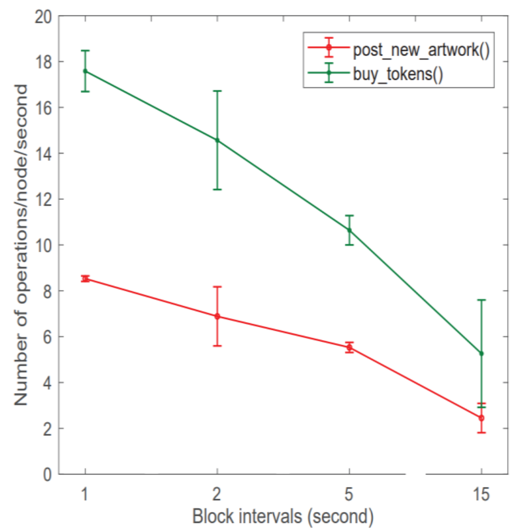

Figure 7. Test under different block interval

4) Check for node crashes: Under certain scenarios, the Geth client crashes. We have observed that transactions like ‘personal.newAccount’ (included in the ‘API add new user()’) consume a significant amount of memory in Geth. In our tests, we made the following observations:

On a node configured with 32GB of memory, Geth can handle up to 70 concurrent add new user() calls without crashing.

Geth crashes when more than 70 add new user() calls are submitted. The operating system kills Geth after it exhausts all 8GB of available memory.

To address this issue, we attempted to enable 32GB of swap memory on the server. We found that Geth was able to process up to 96 concurrent add new user() calls with this configuration. However, during the process, Geth utilized 32GB of physical memory and an additional 9.1GB of swap memory. this took 914 seconds to complete all the calls. In comparison, without using swap memory, it only took about 20 seconds to complete 64 calls. This clearly indicates a degradation in performance.

D. The system's bottleneck

Based on our performance tests, we have identified the following observations:

1. Performance bottleneck: The performance bottleneck in our system lies in the execution of Geth IO.
2. Improving system performance: To enhance the total performance of system, it is important to improve the hardware configuration of the nodes.

According to [15], Ethereum utilizes LevelDB as the database for storing key/value pairs. Accessing the database becomes irregular due to the discrete nature of hashing. While LevelDB performs well in continuous reading/writing operations, it suffers in random key access. As the volume of data storage increases, the time (t) required for accessing LevelDB also increases. In certain cases, where data does not hit the LevelDB cache frequently, the capability of the system degrades. Additionally, Geth consumes significant memory during certain transactions, such as personal.newAccount, and it may crash when multiple memory-consuming transactions are received.

To address this, we suggest enabling swap memory on the nodes to improve system stability, even though it may slightly degrade performance. Based on the performance test results, we recommend allocating 4GB of swap space on the nodes. This adjustment improves system stability without significantly impacting performance.

VI. CONNECTED WORK

Here we provide a comprehensive overview of the relevant literature which is closely related to our research. For more detailed studies on blockchain and its various applications, we recommend referring to [1] and [16].

Digital assets in art Sector: Within the context of blockchain technology, artworks can be regarded as digital assets that could be securely stored and managed. The inherent characteristics of the blockchain, such as authenticity, traceability, and immutability, offer robust protection for each artistic masterpiece. Typically, blockchain-based solutions assign a unique identifier or token to each artwork, often implemented through smart contracts. Many protocols are developed to facilitate the representation and exchange of non-financial assets in the form of tokens on the blockchain platform.

Blockchain Solutions: Given the need for authenticity and security in handling digital assets, blockchain technology emerges as a pivotal choice. Three primary options for implementing blockchain solutions are private blockchains, consortium blockchains, and public blockchains. Considering the certain security requirements that are with assets, consortium-based solutions often strike a balance between performance and security. The properties associated with asset-based ownership are deployed on the application layer of the blockchain and governed by predefined rules encoded in smart contracts. The successful deployment of numerous applications on block-chain technology has contributed to the overall maturation and advancement of the infrastructure. Our proposed solution aims to provide a robust trading infrastructure for the art market while serving as a paradigm for other high-value commodities.

Privacy Protection: Safeguarding the privacy of valuable digital art assets is of paramount importance. Privacy concerns can be broadly categorized into identity privacy and transaction privacy. Identity privacy focuses on preventing the public disclosure of real identities associated with specific transaction records, as various analytical methods, including anti-money laundering and Know Your Customer (KYC) procedures, can unveil usage patterns and transaction behavior. Transaction privacy pertains to concealing essential transaction details within the ledger, such as transfer values and account paths. Malicious actors may attempt to monitor or analyze accounts with substantial asset holdings. To address these challenges, various privacy-preserving techniques are proposed for blockchain system. For instance, [19] introduced mixers to obfuscate relationships between individuals, while Maxwell proposed Confidential Transactions along with range proof schemes. Additionally, privacy-preserving protocols based on ring signatures that are implemented in [20] and [21]. Moreover, [22] employed the Paillier cryptosystem to hide transaction amounts, and [23] presented a comprehensive solution to render sensitive data unreadable to the public. In our system, we prioritize robust chain security and implement security measures at the web server and back-end layers. This approach provides a comprehensive balance between system performance and security considerations

VII. CONCLUSIONS

Here we have introduced the art-chain, a blockchain-based network that enables the registration, tracking, protection, and provenance of artworks. Throughput Analysis: The throughput of a blockchain network is influenced by factors such as block interval, transaction size, and network congestion. By adjusting the block interval and optimizing transaction processing ,we can improve the system's overall throughput. Additionally, the using efficient APIs that primarily query information from the chain can achieve high throughput, while APIs involving transactions may experience lower parallel performance.

Hardware Configuration: The performance of the system is significantly impacted by the hardware configuration of the nodes. Memory-intensive processes like Geth can lead to crashes if memory limits are exceeded. Enabling swap memory may result in performance degradation. It is crucial to strike a balance between system stability and performance by carefully configuring the hardware and considering the limitations of the infrastructure.

Database Considerations: The choice of database system, such as LevelDB, can impact the system's efficiency in accessing and storing data. While LevelDB performs well for continuous read/write operations, it may degrade in performance for random key accesses. As the volume of stored data increases, the access time may also increase, affecting overall system efficiency. Exploring alternative database solutions may help address these limitations and improve performance.

Blockchain for Art-assets:

Block-chain tech will offer significant advantages for managing digital assets, especially in the art sector. Its inherent properties of authenticity, traceability, and irreversibility can safeguard digital artworks effectively. Assigning unique IDs or tokens to each artwork using smart contracts ensures proper asset management and facilitates secure trading and ownership verification.

Privacy Protection: Protecting the privacy of valuable digital art assets is crucial. Identity privacy and transaction privacy are two aspects which are need to be addressed. Various techniques, such as mixers, Confidential Transactions, and encryption schemes, can be employed to enhance privacy in blockchain systems. Implementing security measures at different system layers can ensure comprehensive privacy protection while considering the performance and security trade-offs.

In conclusion, by optimizing system performance, improving hardware configurations, considering database efficiency, and addressing privacy concerns, we can create a more effective and secure system for managing digital assets, particularly in the art market. Further research can focus on optimizing specific components, conducting extensive testing, and exploring advancements in blockchain technology to enhance system performance and scalability

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