INNOVATIVE DIGITAL OWNERSHIP AND COLLECTIBLES VIA PROOF OF STAKE (POS) AND NON-FUNGIBLE TOKENS (NFTS)

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Abstract: The merger of Proof of Stake (PoS) with Non-Fungible Tokens (NFTs) might revolutionize digital ownership and collections. PoS's impact on NFT generation, administration, and security will be examined to create a sustainable, energy-efficient framework. PoS systems' environmental impact compared to Proof of Work (PoW), economic effects on producers and collectors, and digital asset security advantages are examined. The purpose is to explain how PoS may transform the NFT ecosystem and improve digital ownership models. This study highlights the complementarity between blockchain technology and digital assets, suggesting PoS might fuel innovation in the fast-changing digital collectibles industry. The results will inform sustainable and safe blockchain application discussions. Results from Digital Asset Ownership indicate 5 owners' digital ownership distribution. A % random sample was collected for 3 Assets. Values vary from 10-30 for Asset 1, 10-40 for Asset 2, and 10-30 for Asset 3. Fluctuation of Ownership from January to May 2024: Asset 1 20-30, Asset 2 35-42, Asset 3 15-25. In the correlation between ownership concentration and asset value for Top 1–5, Asset 1 ranges from 50–100, Asset 2 from 40–90, and Asset 3 from 60–95.

Keywords: Digital Ownership, Proof of Stake, Non-Fungible Tokens, Blockchain Technology, Sustainability

I. INTRODUCTION

Blockchain has transformed digital ownership and asset management. PoS and NFTs are major advances in this sector. These technologies for producing, managing, and safeguarding digital assets promise to transform businesses by changing ownership and value transfer paradigms. PoS-NFT integration to improve digital ownership and collections is the main goal. The objective is to create a framework that uses PoS and NFTs for more sustainable and efficient digital asset management by studying their features. Studying how PoS might be a more energy-efficient alternative to the environmentally damaging Proof of Work (PoW) approach is a priority. The goals also include examining the economic effects on NFT inventors, collectors, and investors. The report evaluates PoS security innovations to show how they help safeguard digital assets from theft, fraud, and other cyber threats. The overall objective is to demonstrate how PoS may improve NFT ecosystem scalability, security, and sustainability.

Creating ways to smoothly link PoS mechanisms with NFT platforms will strengthen the digital ownership concept. A better grasp of PoS and NFT synergies and how they may promote digital collectibles market innovation is expected.

Analysis of PoS and NFTs' functions in digital asset management advances blockchain technology conversation. The paper shows how blockchain networks might become more sustainable and safer by emphasizing PoS over PoW. In this framework, NFTs have promise beyond digital treasures, indicating applications in real estate, intellectual property, and digital identity verification. The contribution includes actual NFT market restrictions remedies. The initiative attempts to increase NFT usage by tackling scalability and security challenges. The study also persuades stakeholders to invest in and promote PoS-NFT integration by showing its economic advantages.

It analyses PoS and NFTs in the blockchain ecosystem. This contains a comprehensive look at PoS algorithms, their functioning, and their benefits over PoW. The scope also includes NFTs' indivisibility, uniqueness, and capacity to represent digital and physical asset ownership. The work integrates these two technologies to give a comprehensive perspective of digital ownership innovation. Practical applications and case studies of PoS and NFTs in diverse sectors are covered. This involves examining present and prospective use cases, market trends, and regulatory environments that may affect technology acceptance and growth. Technical, economic, and regulatory hurdles to adoption will also be examined. The paper identifies these difficulties and proposes solutions to create a more sustainable and safe digital future. Section 2 summarizes Non-Fungible Tokens utilizing Proof of Stake. Section 3 discusses NFT Proof of Stake methods. Section 4 retrieves findings from multiple datasets. Summary of NFT Proof of Stake methods. Section 5 finishes conclusion.

II. RELATED WORKS

While counterfeit NFTs are now subject to a centralized human censor, decentralized censorship may be possible in the future thanks to the deployment of AI models in smart contracts. When compared to Ethereum, Solana's gas prices are cheaper, and its minting process is friendlier to the environment. A possible decrease in hashing and, eventually, gas costs, may result from Ethereum's switch to proof-of-stake from proof-of-work [1]. PoS and other newer methods are being investigated and potentially used to lessen this energy need. The NFT market stands to gain from these modifications as they make blockchain operations more sustainable and have the potential to reduce costs, speed up transactions, and increase efficiency. The evolution of cross-chain technologies is another front of innovation. Thanks to this innovation, NFTs may be moved freely across other blockchain systems [2]. When it comes to new kinds of digital assets, nobody has yet explored how far the international investment regime can go in terms of non-tangible assets. NFTs could be a good example to see where the regime's scope ends and where it begins [3]. As an example of a consensus mechanism, PoS depends on the honesty and logic of a system stakeholder to prevent the depreciation of the currency. The only criterion for selecting the consensus leader in PoS is her financial investment in the network [4].

Scalability may be greatly affected by lightweight consensus procedures. PoS and other computation-light mechanisms may improve scalability by reducing the amount of time and energy needed to validate transactions. The capacity to handle several transactions in parallel is one way that parallel processing might improve scalability. The use of parallel computing, which increases network throughput, may accomplish this [5]. The elimination of Ethereum's cumbersome PoW consensus mechanism in favor of its more simplified PoS counterpart. The launch of the NFT market stands out as the most revolutionary use of blockchain technology among them. NFTs provide a new way to prove digital ownership, which increases the value of creative works like paintings, video game assets, and musical compositions [6]. The blockchain system was deployed using this, with the PoS consensus process being used for better scalability and security. Three systems have been developed to address this issue: the Decentralized Identity Verification system, which verifies the legitimacy of all participants; the Transparent Charity Application, which encourages open and responsible fundraising and donations; and the NFT Reward System, which assigns a unique digital asset to commemorate and reward each donation [7]. Binance Smart Chain (BSC) is a popular alternative among developers looking to construct decentralized apps with minimal transaction costs. It is based on a PoS consensus process, which makes it quicker and cheaper to operate compared to the Ethereum blockchain. By using a proof-of-stake multichain marketplace, NFTs can verify that the vendor is reliable and honest [8].

PoW requires a substantial amount of computing power and energy use. The more energy-efficient PoS technique is only one additional leader-based option. Without solving complicated issues, validators are selected using several factors, including their financial interest in the coin [9]. To make collections immutable and eternal, the KAPU system was built using a Delegated PoS (DPoS) system, which, unlike the traditional POS paradigm, does not need the whole network to verify a transaction [10]. To enhance throughput and guarantee privacy, this framework introduces a Reputation-based Delegated PoS (RDPoS) consensus process that uses a structure of regular nodes, proxy nodes, and miner nodes. The RDPoS algorithm is shown to have greater performance according to the empirical examination of its throughput during transactions [11]. The amount of bitcoin that validators own and are prepared to "stake" as collateral determines their ability to issue new blocks. Aside from DPoS and PoA, other consensus techniques include PBFT and Practical Byzantine Fault Tolerance [12].

Full support for studios moving to Web3, including infrastructure, NFT markets, marketing, and their own games, is also increasing in the Web3 native ecosystem. Studios making the transition to Web3 are also benefiting from the ecosystem's growing complete support for their games, infrastructure, and NFT markets [13]. To validate transactions and add new blocks to the blockchain, various blockchain networks use different consensus methods, such PoW and PoS. Before a new block of transactions can be added, participants must agree upon it. DPoS and PoS are two of several consensus methods that were developed to address the energy-intensive nature of PoW. [14]. Depending on the blockchain protocol in use, a consensus process (PoW or PoS) verifies and expands upon blockchain transactions on the ledger. Blockchain technology has several uses outside of the cryptocurrency industry. Although blockchain was first implemented for use in cryptocurrency, it has now found its way into many other industries, such as voting systems, healthcare, real estate, finance, and supply chain management, among others [15]. Ethical questions about technology's long-term viability and its effect on the environment arise from this. A major ethical aspect is the exploration of greener alternatives, such as blockchains based on PoS [16].

To generate new blocks, validators must first secure a certain quantity of bitcoin. A group of delegates are elected by the token holders to verify transactions and generate blocks. Decentralized apps thrive on the Solana blockchain network's excellent speed and security. Solana achieves outstanding throughput and low latency by using a novel hybrid consensus method that merges PoS with Proof-of-History (PoH) [17]. A committee that is constantly changing to accommodate new block miners and eliminate old ones is constructed using a sliding-window technique. An epoch-based committee selection mechanism that employs a PoS based blockchain to guarantee that all nodes are on the same page about the updated committee. DPOS consensus procedure is executed by a committee that EOS.IO organizes with each round's 21 producers [18]. Public blockchains use consensus procedures such as PoW or PoS to guarantee security and integrity. By implementing these safeguards, the network is protected from any hostile or illegal activity. Blockchain networks employ the PoS consensus method, which assigns network ownership or shares to validators who then generate new blocks. If they want to be a validator on PoS, participants need to show that they hold a certain number of tokens or cryptocurrencies [19]. By switching from PoW to PoS consensus, Ethereum was able to cut its power usage by more than 99.9 percent. Any scale of public or private blockchain may benefit from Proof-of-Stake's practicality and efficiency. When it comes to maintaining an equitable network, it does have a few downsides. Due to unfair incentivization, other miners may lose interest in participating in a PoS network since the miner with greater stakes always has the greatest chance to win the voting process and mine blocks [20].

III. METHODS AND MATERIALS

PoS and NFT provide a gripping story about digital ownership and collectibles. PoS, an energy-efficient blockchain validation consensus technique, meets NFTs, unique digital assets validated on the blockchain. This synergy changes digital ownership perception and transaction. Unlike typical cryptocurrencies, NFTs are unique and scarce, giving producers and collectors unparalleled potential. As PoS improves blockchain sustainability and scalability, NFTs allow artists to tokenize their work for guaranteed ownership and digital asset exchange. The combination of PoS and NFTs may alter art, gaming, and intellectual property rights, ushering in a new age of digital ownership.

A. Traditional Proof of Stake

Traditional Proof-of-Stake validators are chosen based on their token ownership and willingness to "stake" as collateral. Traditional PoS is crucial to blockchain networks since validators are chosen by token ownership and stake. This protocol prioritizes network security, transaction validation, and consensus preservation without the energy costs of Proof of Work. PoS offers reduced energy use, increased scalability, and more token holder financial incentives. PoS is superior for long-term blockchain operations long-term because of these advantages. Classic PoS can perform transactions faster and cheaper, making it useful for NFTs, governance, and Decentralized Finance (DeFi). PoS delivers a decentralized and safer environment with the staking mechanism, attracting and retaining users. The stake is substantially bigger than rewarding, therefore financial motive will deter peers from lying. We represent blockchain as entangled data in IBM quantum experience's NFT. Figure 1 displays the flowchart for creating token and encoded into blockchain.

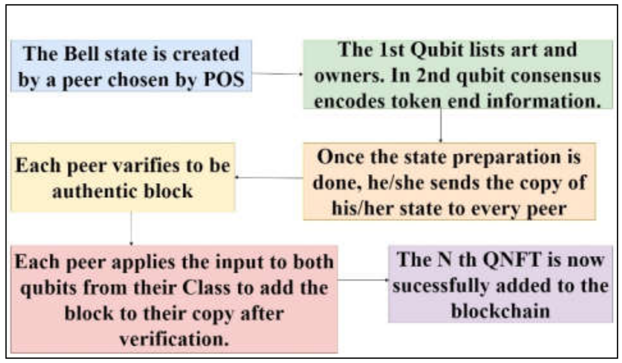

Fig. 1 Flowchart for creating token and encoded into blockchain

B. Delegated Proof of Stake

In DPoS, token holders vote for a few delegates to maintain the blockchain and validate transactions. DPoS helps blockchain governance by enabling token holders to pick delegates who confirm transactions and operate the network. Increasing transaction speed, network security, and democratic decision-making are its main goals. Figure 2 shows the proposed operational flowchart for the metaverse system, including transaction creation, network data exchange, incentive mechanisms, consensus modules, and blockchain storage.

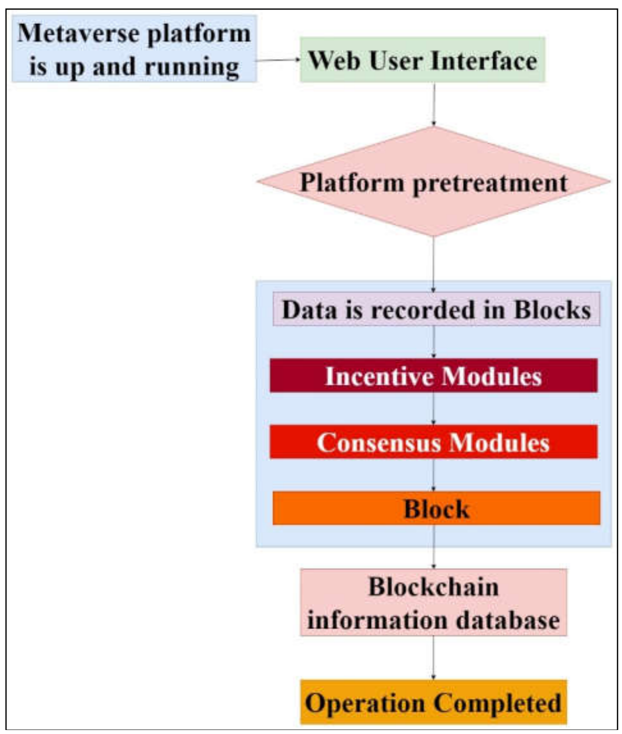

Fig. 2 Operational flowchart of the NFT-based blockchain-oriented framework

DPoS has higher scalability, transaction confirmation speeds, and energy efficiency than PoW systems. Blockchain applications like DeFi, governance frameworks, and NFTs leverage DPoS. DPoS allows certain use cases to transact fast and inexpensively, making the network more inclusive. Token holders electing delegates creates a more democratic and transparent governance mechanism, which fosters community involvement and ensures network stability. This participative strategy promotes sustainable and scalable growth while protecting the blockchain's integrity and efficiency. To begin a transaction, clients must create their own apps in the blockchain-based Metaverse. Users get unique NFTs to generate block transactions after creating their apps.

C. Bonded Proof of Stake

Validators must bond their tokens to participate in BPoS network consensus. Blockchain networks use Bonded Proof of Stake (BPoS), which requires validators to obtain a particular quantity of tokens as collateral to validate transactions and consensus procedures. BPoS prioritizes decentralized consensus, validator commitment, and network security. By making harmful activities costly, encouraging long-term validator involvement, and saving energy, BPoS enhances security over PoW. It has additional major benefits. DeFi, governance models, and NFTs are among the various blockchain applications that leverage BPoS. Due to its excellent security, BPoS makes the network trustworthy and transactions efficient. The bonding requirement encourages validators to act in the network's best interest to ensure stability and promote sustainable blockchain behaviour. This technique supports a safer, scalable, and environmentally friendly blockchain infrastructure. Energy providers with authority approve transactions on an energy blockchain. Other network organizations that merely purchase power cannot validate. Figure 3 illustrates PoS blockchain operation.

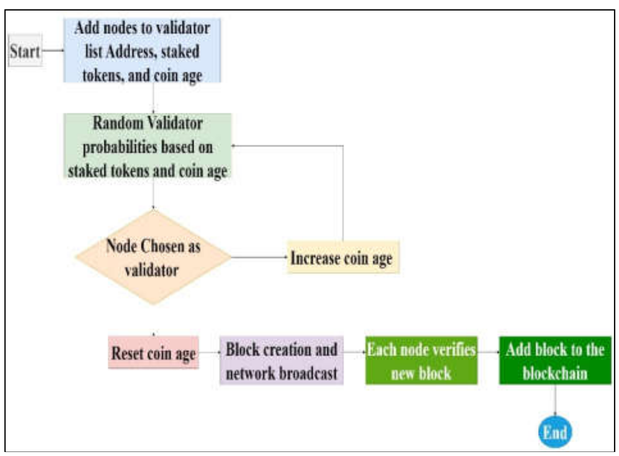

Fig. 3 Proof of stake flowchart

D. Nominated Proof of Stake (NPoS)

Token holders may designate validators via NPoS, and their stakes dictate block creation competition. Blockchain technology uses Nominated Proof of Stake (NPoS) to protect the network and confirm transactions. Token holders may designate validators. NPoS aims to decentralize validation, increase consensus accuracy, and secure networks. NPoS offers more democratic validators, less centralization, and greater community governance. Blockchain initiatives like NFTs, DeFi platforms, and dApps leverage NPoS. These applications benefit from NPoS's safe, scalable, and fast transaction processing. By letting token holders pick validators, NPoS encourages network activity and responsibility. This keeps the blockchain ecosystem stable and growing. PDPoS, a redesigned DPoS schema, reduces transaction cost and improves transaction efficiency per second. Figure 4 shows how the PDPoS consensus allows blockchain to add a Layer 2 network to the current network.

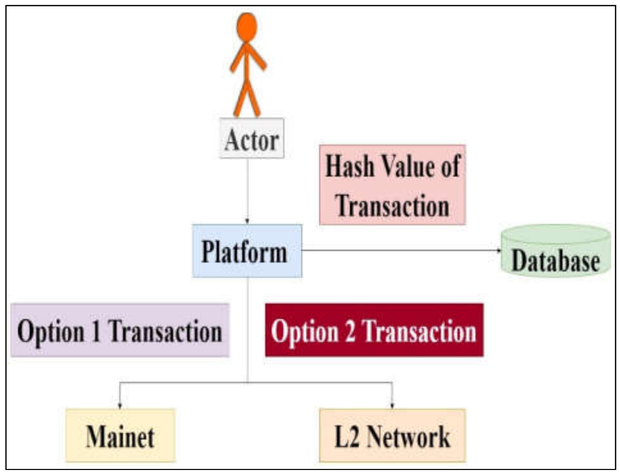

Fig. 4 A Revised L2 Solution on DpoS

E. Hybrid Proof of Stake (Hybrid PoS)

Figure 5 depicts common consensus techniques for putting AI on the blockchain.

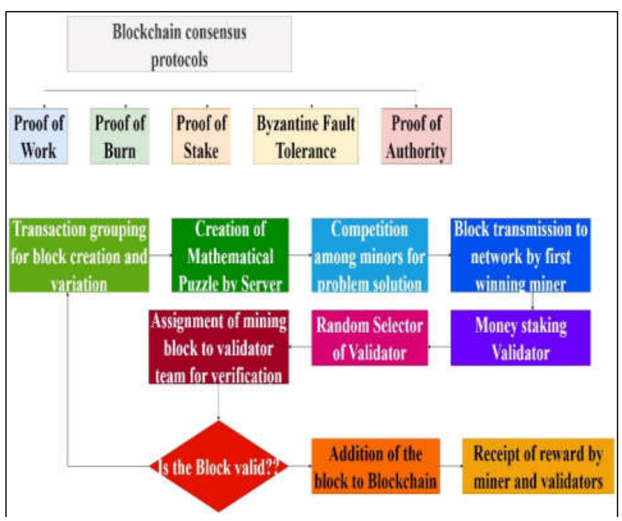

Fig. 5 Artificial intelligence applications leverage blockchain consensus methods.

BFT and PoW are two alternate consensus procedures that may be used in Hybrid Proof of Stake (Hybrid PoS). Hybrid PoS integrates different consensus methods to increase blockchain performance. Balances PoS's benefits with PoW or BFT's to improve security, scalability, and decentralization. This method highlights the necessity for a strong network infrastructure to support blockchain industry growth and innovation. Readers may study novel or less generally recognized protocols such as Proof of Retrievability (PoR), Proof of Ownership (PoO), Proof of Exercise (PoE), and Proof of Luck (PoL).

III. RESULTS AND DISCUSSIONS

LPoS token holders may lease their tokens to validators to increase their staking power. Leased Proof of Stake (LPoS) makes blockchain networks more accessible. Token holders may indirectly participate in blockchain consensus by leasing tokens to validators. They may avoid complete node deployment. Figure 6 shows the "Digital Asset Ownership" dataset's PoS and NFT distribution of digital ownership. Different digital assets and owners are in each row and column. Decentralized digital ownership is shown by the shade intensity of each participant's stake or ownership proportion.

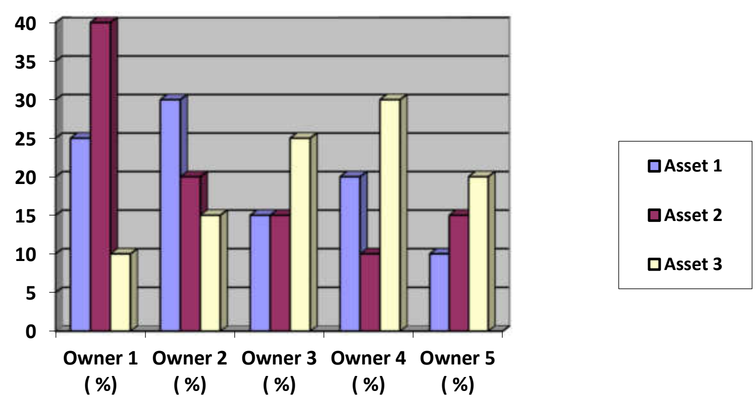

Fig. 6 Distribution of Digital Ownership via (PoS) and (NFTs)

Table 1 shows the many facets of merging PoS and NFTs to transform digital ownership and collections. Security, Decentralization, Scalability, User Engagement, Market Accessibility, and Innovation are discussed in terms of their responsibilities, advantages, and effect. This paradigm helps explain how PoS and NFTs create a safe, scalable, user-centric digital marketplace. Each element shows how PoS methods and NFTs may improve digital transaction and asset management transparency, efficiency, and inclusivity for a variety of sectors, from decentralized banking to digital art and entertainment.

TABLE. 1 Aspects of innovative digital ownership and collectibles via pos and NFTS

Aspect	Role	Functions	Benefits	Scope
Security	Safeguard assets	Validate transactions, block creation	High security, reduced fraud	All digital assets
Decentralization	Distribute control	Network consensus, user empowerment	Eliminates single points of failure	DeFi, gaming, art
Scalability	Manage growing user base	Efficient processing, lower costs	Supports large volumes of transactions	Global market reach
User Engagement	Increase user investment	Reward mechanisms, community governance	Enhanced user loyalty and retention	Community-driven platforms
Market Accessibility	Lower barriers to entry	Simplified transactions, reduced fees	Broader public participation	Emerging economies, new users
Innovation	Drive new use cases	Creative content management, trading	Novel experiences, unique assets	Entertainment, education

Figure 7 shows how ownership shares for chosen digital assets in the "Digital Asset Ownership" dataset change over time. Each row represents an asset and each column a time. Our observations of ownership percentage changes over time reveal the dynamic character of digital ownership distribution, impacted by market dynamics, trading activity, and network engagement.

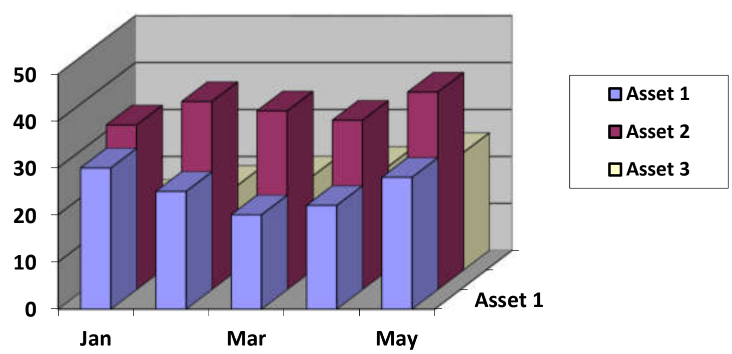

Fig. 7 Fluctuation of Ownership Shares Over Time

Table 2 describes how PoS and NFTs might innovate digital ownership and collections. It lists specialized uses, broad applications, and benefits. NFT authentication improves security and gives irrefutable evidence of ownership in digital art and rare artifacts. In gaming and real estate, fast asset transfers boost efficiency and minimize latency. Cheap transaction costs make DeFi platforms and digital markets more accessible and promote participation. Data verification is assured by transaction transparency, essential for art provenance and supply chain confidence. Global growth of virtual products and music generates economic prospects, while user empowerment in DAOs and community initiatives promotes decentralization and community participation. PoS and NFTs make digital marketplaces more safe, efficient, and user centric.

TABLE. 2 Dynamics of Innovative Digital Ownership with PoS and NFTs

Aspect	Uses	Applications	Advantages
Authentication	Verify ownership	Digital art, rare collectibles	Enhanced security, proof of ownership
Transaction Speed	Quick transfer of assets	Gaming, real estate	Efficiency, reduced latency
Cost Efficiency	Low transaction fees	DeFi, marketplace	Accessibility, increased participation
Transparency	Public verification of transactions	Art provenance, supply chain	Trust, reliable data
Market Expansion	Broader access to global markets	Virtual goods, music	New economic opportunities
User Empowerment	Voting rights, governance	DAOs, community projects	Decentralized control, engagement

Description: Sharding involves partitioning the blockchain into smaller, more manageable pieces called shards, each capable of processing transactions independently. Scalability: Sharding significantly enhances the scalability of NFT platforms, allowing for higher transaction volumes without compromising speed or performance. **Reduced Congestion:** By distributing the workload across multiple shards, the likelihood of network congestion is reduced, ensuring a smoother experience for NFT transactions. Table 3 lists the main problems, consequences, constraints, and future potential for novel digital ownership and collectibles using PoS and NFTs. Scalability, regulatory, security, market volatility, user adoption, and interoperability all face network congestion, ambiguous legal frameworks, and security vulnerabilities. Slower transaction times, market uncertainty, and asset loss affect the ecosystem, reducing usability, compliance risks, and trust.

TABLE. 3 Challenges and prospects in innovative digital ownership with PoS and NFTS

Aspect	Challenges	Impact	Limitations	Future Scope
Scalability	Network congestion	Slower transaction times	Reduced usability during peaks	Improved algorithms, sharding
Regulatory	Unclear legal frameworks	Market uncertainty	Compliance risks	Harmonization of global laws
Security	Vulnerability to hacks	Potential loss of assets	Trust issues	Advanced cryptographic methods
Market Volatility	Price fluctuations	Investment risks	Barrier to new entrants	Stablecoin integration, hedging
User Adoption	Lack of understanding and trust	Slow growth	Limited market size	Education, user-friendly tools
Interoperability	Compatibility issues between networks	Limited functionality	Restricted asset flow	Cross-chain solutions

Figure 8 shows the association between ownership concentration and asset value. Each row represents a unique digital asset, and each column shows the top stakeholders' ownership proportion. How ownership distribution affects digital collectibles and asset values and market dynamics by studying this connection is being studied. Assessing the durability and stability of PoS and NFT digital ownership ecosystems requires understanding this association.

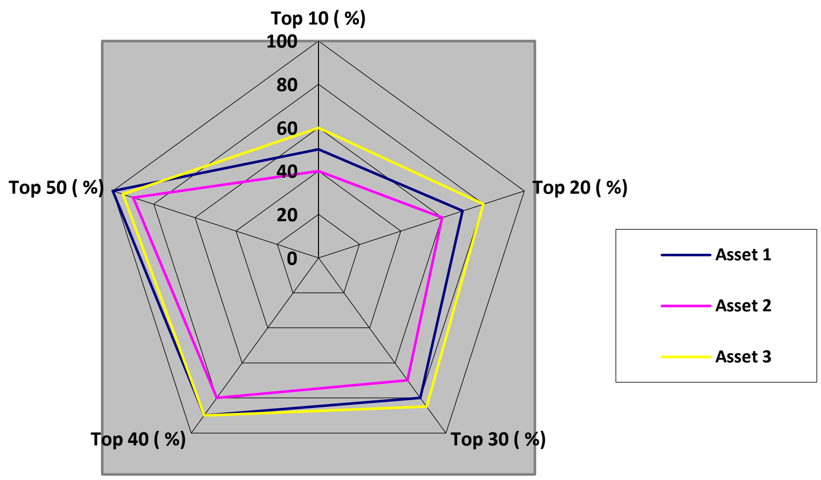

Fig. 8 Correlation between Ownership Concentration and Asset Value

IV. CONCLUSIONS

Innovative digital ownership and collections using PoS and NFTs face many hurdles. Scalability, regulatory uncertainty, and PoS integration with blockchain infrastructures are major difficulties. Market instability and early NFT adoption may further limit uptake. PoS protocol refinement to improve NFT ecosystem efficiency, security, and sustainability is the objective despite these challenges. This objective might boost the digital collectibles industry by fostering sustainability and security. Further advances in PoS and NFT technology may impact real estate, intellectual property, and digital identity verification beyond collectibles. It may promote innovation, a more sustainable and secure digital economy, and digital asset ownership and management. Digital Asset Ownership Distribution for 5 owners random sample data in % for 3 Assets. Values vary from 10-30 for Asset 1, 10-40 for Asset 2, and 10-30 for Asset 3. Fluctuation of Ownership from January to May 2024: Asset 1 20-30, Asset 2 35-42, Asset 3 15-25. In the correlation between ownership concentration and asset value for Top 1–5, Asset 1 ranges from 50–100, Asset 2 from 40–90, and Asset 3 from 60–95.

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