"NFT Marketplace"

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Abstract— The rapid growth of blockchain technology has transformed the creation and exchange of digital assets through Non-Fungible Tokens (NFTs). Despite this progress, existing NFT marketplaces continue to face significant challenges, including high transaction costs, centralized metadata storage, lack of transparency in royalty distribution, limited interoperability, and complex user interfaces that hinder adoption by non-technical users. These limitations reduce creator autonomy and restrict the scalability of decentralized digital ownership ecosystems.

To address these challenges, this project presents a fully decentralized NFT Minting and Marketplace Platform designed to support secure, transparent, and user-friendly digital asset creation and trading. The platform leverages Ethereum/Polygon blockchain networks, Solidity-based smart contracts, and decentralized storage using the Interplanetary File System (IPFS). NFTs are minted using ERC-721 and ERC-1155 standards, ensuring interoperability across Web3 ecosystems. A modern web interface built with ReactJS and TypeScript enables users to upload assets, generate metadata, mint NFTs, list them for sale, participate in auctions, and perform peer-to-peer transactions through verified blockchain interactions.

A key contribution of this system is the implementation of smart contract–based royalty automation, which guarantees perpetual royalty payments to original creators during secondary market resales without reliance on intermediaries. Wallet- based authentication through MetaMask ensures secure access and seamless integration with blockchain networks. The decentralized architecture eliminates single points of failure, preserves asset integrity, and prevents unauthorized modification or censorship after minting.

By integrating decentralized storage, automated royalty enforcement, and user-centric design, the proposed platform enhances accessibility, transparency, and trust in NFT marketplaces. This work contributes to the advancement of Web3 infrastructure by providing a scalable and interoperable solution for decentralized digital ownership, supporting creators, collectors, and developers in the evolving blockchain economy.

I. INTRODUCTION

Blockchain technology has emerged as a foundational digital infrastructure that enables decentralized, transparent, immutable, and thrustless data management. Unlike traditional centralized systems, blockchain eliminates the need for a single controlling authority, thereby enhancing security, accountability, and resistance to tampering. While cryptocurrencies represent one of the earliest and most prominent applications of blockchain, the technology's potential extends far beyond financial transactions through the use of smart contracts and standardized token protocols.

One of the most transformative outcomes of blockchain innovation is the development of Non-

Fungible Tokens (NFTs). NFTs are cryptographic tokens that represent unique digital or physical assets, with ownership, provenance, and authenticity permanently recorded on a blockchain. Unlike fungible tokens, NFTs are non-interchangeable due to their unique metadata, which defines attributes such as originality, rarity, and ownership history. This capability has enabled the tokenization of a wide range of assets, including digital art, music, gaming items, virtual real estate, certificates, collectibles, and identity-linked resources.

Since 2020, the NFT ecosystem has experienced rapid global adoption, driven by artists, musicians, content creators, game developers, collectors, and enterprises seeking new models for monetization and digital ownership. NFTs have introduced key concepts such as digital scarcity, tamper-proof provenance, automated creator royalties, interoperable ownership across platforms, and the representation of both digital and real-world assets. As a result, NFTs have become a core component of emerging Web3 ecosystems and decentralized digital economies.

Despite this growth, existing NFT marketplaces face several structural and technical limitations that restrict their long-term sustainability and inclusiveness. Prominent platforms such as Open Sea, Raible, and Foundation often rely on centralized infrastructure for metadata storage, making NFTs vulnerable to data loss or censorship if servers fail. High gas fees on popular blockchains like Ethereum significantly increase the cost of minting and trading NFTs, limiting participation by independent creators and new users. Additionally, royalty distribution mechanisms are often opaque or inconsistently enforced, reducing trust among creators. Many platforms also present steep learning curves, requiring users to understand complex wallet operations, private key management, and blockchain interactions, which discourages mainstream adoption.

Another critical concern lies in platform dependency. Creators and collectors are frequently bound by marketplace-specific policies, fee structures, and governance decisions, which may change over time and undermine user autonomy. These challenges highlight the absence of a standardized, cost-effective, fully decentralized NFT ecosystem that prioritizes user control, transparency, and accessibility.

To address these challenges, this project proposes the design and development of a decentralized NFT Minting and Marketplace Platform built on blockchain and smart contract technologies. The system leverages Ethereum and Polygon networks for secure and scalable transactions, utilizes ERC-721 and ERC-1155 token standards for interoperability, and integrates the Interplanetary File System (IPFS) for decentralized and permanent asset storage. Smart contract–based automation ensures transparent marketplace operations, immutable ownership records, and perpetual royalty enforcement for creators.

The proposed platform also emphasizes user-centric design by incorporating wallet-based authentication, intuitive interfaces, and simplified workflows for NFT creation, listing, auctions, and peer-to-peer trading. By eliminating centralized control, reducing transaction costs, and enhancing transparency, the platform aims to democratize access to NFT ecosystems while preserving the core principles of decentralization.

The objective of this project is to build a scalable, secure, and interoperable NFT marketplace that supports creators, collectors, and developers within the evolving Web3 landscape. By combining decentralized storage, automated royalty mechanisms, and transparent blockchain transactions, the system contributes to the development of sustainable digital ownership models and lays the foundation for broader applications such as decentralized identity, gaming assets, metaverse economies, certificate verification, and tokenized physical commodities.

II. LITERATURE SURVEY

Recent advancements in blockchain technology, decentralized storage, and smart contract automation have significantly influenced the evolution of digital asset management systems. Research in this domain has focused on token standards, decentralized storage architectures, smart contract security, NFT market dynamics, and decentralized marketplace design, forming the foundation for modern NFT ecosystems.

One of the earliest and most influential contributions to NFT development is the introduction of standardized token protocols on the Ethereum blockchain. The ERC-721 token standard, proposed by the Ethereum Foundation between 2018 and 2019, established the first widely adopted framework for representing unique, non-fungible digital assets. It defined essential interfaces for token ownership, transfer, and metadata association through Uniform Resource Identifiers (URIs). While ERC-721 enabled the creation of unique NFTs, it was limited in scalability and gas efficiency. To address these constraints, the ERC-1155 standard was later introduced, supporting both fungible and non-fungible tokens within a single contract and enabling batch minting and transfers. This improvement significantly reduced transaction costs and enhanced interoperability across wallets and marketplaces, making ERC-1155 particularly suitable for large-scale NFT platforms.

Decentralized storage has also emerged as a critical component of resilient NFT systems. Benet (2015) introduced the Interplanetary File System (IPFS), a peer-to-peer distributed file system that uses content- addressed hashing to store and retrieve data. Unlike centralized storage solutions, IPFS distributes files across a global network of nodes, ensuring decentralization, immutability, censorship resistance, and high availability. In the context of NFTs, IPFS plays a vital role in storing digital assets and metadata in a manner that preserves long-term accessibility and prevents data loss caused by centralized server failures. Many studies emphasize that decentralized storage is essential for maintaining NFT integrity and trustworthiness.

Smart contract security has been extensively studied due to the irreversible nature of blockchain transactions. Atzei et al. (2018) conducted a comprehensive analysis of vulnerabilities in Ethereum smart contracts, identifying critical threats such as reentrancy attacks, timestamp dependency, gas-limit vulnerabilities, integer overflows, and improper fallback functions. Their findings highlight the necessity of adopting secure development practices when designing decentralized applications. The study recommends mitigation techniques including modular contract design, defensive programming patterns, and the use of well-tested libraries. These insights have directly influenced the adoption of standardized security frameworks such as OpenZeppelin and established best practices for secure smart contract development.

The economic behaviour of NFTs has also been examined in academic research. Nadina et al. (2021) analysed large-scale NFT transaction data to understand the factors influencing NFT valuation and market dynamics. Their study revealed that scarcity, creator reputation, rarity attributes, and historical ownership significantly impact NFT prices. The research further emphasizes the importance of trust, verified ownership, and immutable provenance in sustaining long-term NFT value. Blockchain-based transparency was identified as a key driver for reducing fraud and increasing confidence among participants in NFT markets.

Decentralized marketplace architectures have been explored as an alternative to traditional centralized platforms. Zhang et al. (2017) investigated decentralized trading systems and demonstrated how peer-to-peer marketplaces can eliminate intermediaries, reduce transaction manipulation, and improve fairness through public ledger auditability. Their work highlights the importance of smart contract automation, transparent transaction records, and decentralized governance in building trustless digital marketplaces. These architectural principles form the backbone of modern Web3 applications and NFT trading platforms.

Across the existing literature, a consistent theme emerges: the need for interoperable token standards, decentralized storage, secure smart contract execution, transparent economic models, and peer-to-peer trading mechanisms. While current studies address individual components of NFT ecosystems, limited research integrates all these elements into a unified, user-centric NFT marketplace with automated royalties and decentralized asset storage. This gap motivates the development of the proposed platform, which combines standardized token protocols, IPFS-based storage, secure smart contract design, and decentralized marketplace architecture to deliver a scalable and transparent NFT trading ecosystem.

Author & Year	*Method Used*	*Key Findings*	*Limitation*
Ethereum Foundation (2018–2020)	*ERC-721 & ERC-1155 Token Standards*	*Enabled creation of unique and semi-fungible tokens; improved interoperability and gas efficiency*	*Does not address marketplace logic, royalties, or storage mechanisms*
Benet (2015)	*IPFS (Decentralized Storage)*	*Ensures content-addressed storage, immutability, censorship resistance, and high availability*	*Retrieval speed depends on node availability; requires pinning services*
Atzei et al. (2018)	*Smart Contract Vulnerability Analysis*	*Identified critical security flaws such as reentrancy and integer overflow; proposed mitigation strategies*	*Focuses on vulnerability classification, not marketplace implementation*
Nadini et al. (2021)	*NFT Market Economic Analysis*	*Demonstrated impact of scarcity, creator reputation, and provenance on NFT value*	*Does not propose technical solutions for NFT platforms*

III. METHODOLOGY

The methodology adopted in this research follows a structured and systematic approach to design, develop, and deploy a fully decentralized NFT minting and marketplace platform. The workflow is divided into multiple stages, beginning with requirement analysis and feasibility evaluation, followed by system architecture design, smart contract development, decentralized storage integration, frontend and backend implementation, testing, and final deployment. Each stage is carefully designed to ensure security, scalability, transparency, and user accessibility within a Web3 environment. The initial stage involved a comprehensive analysis of existing NFT marketplaces, blockchain infrastructures, and user expectations. Key challenges such as high gas fees, centralized metadata storage, limited royalty enforcement, platform dependency, and usability barriers were studied in detail. The feasibility of implementing a decentralized marketplace using Ethereum and Polygon blockchains, Solidity-based smart contracts, IPFS for decentralized storage, and Ethers.js for blockchain interaction was evaluated. This analysis ensured that the proposed system could operate efficiently while remaining cost-effective and accessible to both creators and collectors. Based on the requirement analysis, a modular and scalable system architecture was designed. The platform architecture consists of four major components: a frontend built using ReactJS and TypeScript, a backend developed with Node.js and Express, blockchain smart contracts written in Solidity, and decentralized storage powered by IPFS. The system is designed to support seamless communication between these components through secure APIs and blockchain event listeners. Ethereum and Polygon test networks are utilized during development to validate smart contract functionality while minimizing deployment costs. Smart contracts form the core of the NFT marketplace and are responsible for automating all blockchain-based operations. The developed contracts manage NFT minting, metadata linking, ownership transfer, marketplace listings, bidding mechanisms, auctions, and automated royalty distribution. ERC-721 and ERC-1155 token standards are implemented to ensure interoperability across wallets and platforms. To enhance security and reliability, OpenZeppelin libraries are integrated, and best practices such as the Checks- Effects-Interactions pattern, reentrancy protection, and safe arithmetic operations are followed throughout contract development. To eliminate dependency on centralized servers, digital assets and

NFT metadata are stored using the InterPlanetary File System (IPFS). When a user uploads an asset, it is converted into a content-addressed format and assigned a unique Content Identifier (CID). This CID is permanently embedded within the NFT metadata and stored on the blockchain, ensuring immutability, censorship resistance, and long-term availability of digital assets. Public IPFS gateways are utilized to enable reliable asset retrieval across the platform. The frontend of the marketplace is developed using ReactJS and TypeScript to provide a responsive, intuitive, and user-friendly interface. The frontend includes modules for NFT minting, marketplace browsing, auctions, user profiles, wallet connection, and transaction dashboards. Wallet-based authentication is implemented using MetaMask, allowing users to securely interact with the blockchain without exposing private keys. The interface is optimized for performance and accessibility, enabling smooth interactions even for users new to blockchain technology. Backend services are implemented using Node.js and Express to support off-chain functionalities. The backend handles user metadata management, transaction history retrieval, NFT display data, and indexing of blockchain events. By listening to smart contract events, the backend maintains an updated representation of marketplace activities, ensuring faster data retrieval and improved user experience without compromising decentralization. Extensive testing and validation are conducted to ensure system reliability and security. Smart contracts undergo unit testing and integration testing using development frameworks such as Hardhat or Truffle. Contract auditing techniques are applied to identify and mitigate potential vulnerabilities. IPFS storage reliability is evaluated to ensure consistent asset availability. Additionally, UI and UX testing are performed with test users to assess usability, transaction clarity, and overall system responsiveness. The final stage involves deploying the platform across multiple environments. Smart contracts are deployed on blockchain test networks such as Goerli or Polygon Mumbai, while the frontend and backend services are hosted on cloud platforms. IPFS public gateways are used to serve decentralized assets and metadata. Continuous monitoring mechanisms are implemented to track system performance, transaction success rates, and network stability, ensuring a reliable and scalable marketplace.

IV. PERFORMANCE METRICS

To understand how well the NextKick system performs in real situations, its effectiveness was examined from two major angles: how accurately it interprets football actions and how efficiently it runs on typical user devices. The first part of the evaluation focuses on the model's ability to correctly recognize and validate football skills in uploaded videos. While overall Accuracy provides a basic indication of correct predictions, it is not sufficient by itself because the dataset does not contain equal amounts of every skill type. Some skills, like dribbling, appear far more often than others, which means the model could seem accurate even if it struggles with the less common actions. For this reason, the F1-Score becomes far more meaningful, as it accounts for both Precision and Recall. A strong F1-Score shows that the system is not only making correct predictions but is doing so consistently across both frequently and infrequently occurring skill categories.

Along with these metrics, confusion matrices were studied to understand in detail where the model performs well and where it tends to make mistakes. These matrices reveal which actions the model sometimes mixes up, such as mistaking a controlled tap for slow-paced dribbling or confusing the first steps of a pass with a shot attempt. These insights make it easier to identify where additional data or better preprocessing may be needed. They also highlight situations in which the model struggles— such as when videos are shaky, poorly lit, or recorded at odd angles—providing a clear direction for improving future versions of the system.

Accuracy alone, however, is not enough for a system like NextKick, which must also run smoothly on a wide range of devices. Because users typically upload videos from their own phones, the system needs to process these videos quickly and with minimal strain on hardware. To evaluate this aspect, metrics such as inference speed, memory usage, and model size were considered. After model optimization and quantization, the detection and tracking components were able to process frames in real time on mid-range CPUs, allowing uploaded videos to be analyzed almost immediately. This responsiveness is essential because long delays would discourage players and scouts from using the platform. Storage and RAM consumption were also monitored to ensure that the system remains lightweight enough for widespread use without requiring high-end devices.

When combined, these evaluations show that NextKick delivers both reliable predictions and practical performance. The system is fast enough to handle real user videos, stable enough to track players throughout the clip, and accurate enough to differentiate between various football skills. This balance of accuracy and efficiency makes it well- suited for grassroots scouting, where players rely on everyday mobile devices and clubs need quick, trustworthy assessments.

V. IMPLEMENTATION

The implementation of the proposed decentralized NFT Minting and Marketplace Platform was carried out through a structured, phase-wise development process. The implementation timeline was divided into multiple stages to ensure systematic progress, modular development, and continuous validation of system functionality. Each phase focuses on a specific component of the platform, ranging from requirement analysis to final deployment and documentation. The initial phase focused on understanding the problem domain and defining system requirements. Market research was conducted to study existing NFT marketplaces, user workflows, and technical limitations such as high gas fees, centralized storage, and inconsistent royalty enforcement. Functional and non-functional requirements were gathered based on creator and collector use cases. Key use cases— including NFT minting, marketplace listing, bidding, buying, selling, and royalty distribution—were identified. Based on feasibility and performance considerations, the technology stack was finalized, comprising Ethereum/Polygon blockchain, Solidity smart contracts, IPFS for decentralized storage, ReactJS with TypeScript for the frontend, and Node.js with Express for backend services. During this phase, the overall system architecture was designed with an emphasis on modularity and scalability. Architectural diagrams were developed to define interactions between the frontend, backend, blockchain network, and decentralized storage layer. Smart contract workflows were designed to represent NFT minting, ownership transfer, marketplace operations, and royalty automation. UI wireframes and prototypes were created to visualize user journeys, including minting interfaces, marketplace pages, wallet connections, and transaction dashboards. The design ensured seamless integration between Web3 components and user-facing modules. Smart contract implementation formed the core of the platform's functionality. ERC-721 and ERC-1155 standards were implemented to support both unique and semi- fungible NFTs. Marketplace contracts were developed to manage listings, bidding, auctions, direct sales, and ownership transfers. Royalty enforcement logic was embedded directly into smart contracts to ensure automatic and perpetual royalty payments to creators during secondary sales. Integration testing was performed using blockchain development frameworks to verify contract correctness, security, and interoperability. Frontend development focused on building an intuitive and responsive user interface using ReactJS and TypeScript. Key modules included the NFT minting page, wallet connection using MetaMask, marketplace browsing, listing and bidding systems, asset preview pages, and user dashboards. Backend services were implemented using Node.js and Express to manage off-chain data such as user metadata, transaction indexing, and NFT display information. Blockchain event listeners were integrated to synchronize on-chain activity with frontend displays, ensuring real-time updates and improved user experience. Decentralized storage integration was achieved using the InterPlanetary File System (IPFS). An IPFS upload engine was developed to handle digital asset uploads and metadata generation. Each uploaded asset was assigned a unique Content Identifier (CID), which was permanently linked to the NFT metadata and stored on the blockchain. This ensured immutability, censorship resistance, and long-term availability of digital assets without reliance on centralized servers. In this phase, all system components were integrated into a unified platform. The frontend was connected to the deployed smart contracts through Web3 libraries, enabling real-time blockchain interactions. Minted NFTs were displayed dynamically within the marketplace, and complete buy/sell workflows were tested to verify transaction accuracy, ownership transfers, and royalty execution. End-to-end testing ensured that users could seamlessly mint, list, purchase, and sell NFTs. Comprehensive testing was conducted to validate system reliability and security. Smart contracts underwent auditing and vulnerability testing, while frontend UI testing ensured usability and responsiveness. Load testing was performed to evaluate platform stability under concurrent user interactions. The platform was deployed on blockchain test networks such as Goerli or Polygon Mumbai, with frontend and backend services hosted on cloud infrastructure and IPFS public gateways. The final phase involved preparing detailed project documentation, including system architecture diagrams, smart contract explanations, and user manuals. The project report was finalized to document the implementation process, design decisions, and technical contributions. This documentation supports future enhancements, maintenance, and academic evaluation.

VI. SOFTWARE REQUIREMENTS SPECIFICATION

The Software Requirements Specification (SRS) defines the functional and non-functional requirements of the proposed decentralized NFT Marketplace Platform. This document serves as a formal reference for system design and development, ensuring that the platform meets the expectations of all stakeholders, including NFT creators, collectors, developers, and administrators. The SRS provides a comprehensive description of system behavior, constraints, and external interactions, forming the foundation for implementation and validation. The primary purpose of this SRS is to formally specify the functional and non-functional requirements of the NFT marketplace. It establishes a clear understanding of system capabilities, operational constraints, and performance expectations, enabling consistent development, testing, and future scalability of the platform. The proposed system is a decentralized web- based NFT marketplace that enables users to mint, buy, sell, and trade Non-Fungible Tokens using blockchain technology. The platform integrates smart contract automation for secure transactions and royalty enforcement, along with decentralized storage using IPFS to ensure data immutability and long-term availability of digital assets. The system is designed to support multiple user roles, including: NFT creators who mint and manage digital assets, NFT collectors who browse, purchase, and trade NFTs, Developers who interact with or extend the platform, Administrators (optional) responsible for monitoring and indexing system activity. Overall Description Product Perspective The NFT marketplace operates as a decentralized application (DApp) built on blockchain infrastructure. It integrates smart contracts deployed on Ethereum or Polygon networks, decentralized storage through IPFS, and a web-based user interface for seamless interaction with blockchain services. The core features of the system include: NFT minting using ERC-721 and ERC-1155 standards, Marketplace listing and asset trading, Decentralized file uploads and metadata storage via IPFS, Automated royalty distribution using smart contracts, Secure wallet-based authentication. The platform supports the following functional requirements: Wallet-based user authentication, NFT minting with metadata generation, Uploading digital assets to IPFS, Retrieval and validation of IPFS Content Identifiers (CIDs), Token creation and ownership management through smart contracts, Viewing detailed NFT metadata and ownership information, Listing NFTs for sale or auction, Automated execution of creator royalties on secondary sales, Wallet balance display and gas fee estimation prior to transactions. The system adheres to the following non-functional requirements: **Scalability:** Support for increasing users and NFT volumes, **Security:** Protection against smart contract vulnerabilities and unauthorized access, **Performance:** Efficient transaction processing and responsive UI, **Maintainability:** Modular architecture supporting updates and enhancements, The overall system architecture is composed of the following layers: Smart contract layer for blockchain logic and automation, Blockchain transaction layer for interacting with Ethereum/Polygon networks, Storage layer using IPFS for decentralized asset management, Application layer for frontend and backend services. The system interacts with the following external interfaces: Blockchain RPC endpoints for transaction execution and state queries, IPFS APIs for decentralized file and metadata storage, MetaMask wallet for user authentication and transaction signing

VIII. REFERENCES

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