**Tab 1**

MetaBazaar: A Robust & Decentralised NFT Exchange

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***Abstract*— Non-fungible tokens (NFTs) have transformed digital ownership and NFT trading. MetaBazar, proposed here, is an ERC-721-based NFT trading platform for effortless purchasing, selling, and trading of NFTs. The application of blockchain technology by the platform ensures transparency, security, and decentralization. Dynamic NFT pricing according to market demand is introduced in MetaBazar, making the digital asset valuation process more efficient. The system is crafted to enable user interactions without wallet authentication for surfing, to ensure ease of use. Moreover, MetaBazar offers a user-friendly interface for the management of assets and transaction records while ensuring on-chain proof of ownership. The solution has the objective of establishing a trustless and efficient marketplace towards building a strong digital economy for NFTs.**

***Keywords— NFT, Smart Contract, Tokenized Assets, Minting, ERC-721, Blockchain, Trading***

# INTRODUCTION

Non-Fungible Tokens (NFTs) have emerged as a revolutionary concept, enabling digital asset ownership, provenance tracking, and monetization [5]. However, most NFT marketplaces are centralized, leading to problems such as high transaction fees, security risks, lack of transparency, and dependence on intermediaries [13]. These issues create barriers for artists, collectors, and investors looking for a secure and affordable way to trade digital assets.

A study by H. Salem [13] shows the analysis of top-selling NFTs on the OpenSea marketplace, the authors found that a substantial portion of metadata is hosted on centralized servers, making them susceptible to various vulnerabilities.

According to a report given in [5] NFTs face significant ambiguities in ownership rights and a lack of standardized. There are no universal standards on consumer protection, taxation, royalties, or dispute resolution for NFT transactions.

To overcome these challenges, our proposed solution is Metabazaar, a decentralized NFT exchange built on Ethereum smart contracts. This platform eliminates the need for intermediaries, allowing users to mint, buy, sell, and auction NFTs in a trustless environment. By leveraging decentralized storage (IPFS) [10] and Layer-2 scaling solutions, it also ensures cost-efficient transactions, enhanced security, and greater user control over digital assets. MetaBazar is designed to address the inefficiencies and risks associated with existing NFT marketplaces by ensuring decentralized metadata storage, secure smart contracts [8], and an innovative pricing model.

# LITERATURE REVIEW

Some research has ventured into the decentralization of NFT marketplaces and blockchain efficiency. Sarumathi et al. [6] suggest a blockchain-based decentralized NFT marketplace that eliminates intermediaries, allowing secure, transparent, peer-to-peer trading. Their platform incorporates royalty enforcement through smart contracts to guarantee ongoing income for creators. Ante [2], however, points out legal issues in NFT ownership and tokenization, highlighting unresolved issues such as intellectual property conflicts and regulatory uncertainty. These gaps in law could make it difficult to implement systems like the one presented by Sarumathi et al. in practice.

On top of decentralization, Zhang et al. [3] compare the performance of NFT platforms based on Hyperledger Fabric and find that it is less expensive, more scalable, and more private compared to Ethereum. This is opposite to typical Ethereum-based implementations, which usually experience scalability bottlenecks. In the meantime, Barrington [7] highlights the significance of metadata within NFT marketplaces, with the argument that variable metadata schemes inhibit pricing precision and liquidity. Their suggestion to employ decentralized storage mechanisms such as IPFS fits nicely into the proposed architectural principles in [6].

Smart contract optimization is another very important area of focus. Hu et al. [14] and the Solidity documentation [8] provide several smart contract optimization methods including bytecode compression and storage minimization, which have the purpose of minimizing gas usage and enhancing execution efficiency. The optimizations are highly important for Ethereum-based NFT platforms, which often experience excessively high transaction costs.

Our suggested work combines these insights by creating decentralization for secure NFT exchange, imposing royalty logic via smart contracts, enhancing metadata application for pricing and analytics, and utilizing IPFS for storage robustness, as well as embracing gas optimization for efficient execution. Overall, these pieces seek to enhance NFT marketplace security, scalability, and transparency.

# NOVELTY AND IMPACT

MetaBazaar has introduced a decentralized NFT marketplace on Ethereum's ERC-721 standard that overcomes certain major limitations inherent in existing platforms through dynamic NFT pricing, Layer-2 scalability, and decentralized storage solutions. Unlike traditional NFT marketplaces, it is equipped with an adaptive pricing framework that adjusts based on market demand, thus ensuring more equitable valuations and preventing speculation. Through Layer-2 solutions, MetaBazaar significantly reduces transaction costs and enhances scalability, thus making NFT trading more efficient. Additionally, it uses IPFS for decentralized storage of metadata, thus preventing the risks typically associated with central servers. The platform also optimizes accessibility by enabling wallet-free browsing, thus reducing barriers to entry for new users. Additionally, its trustless smart contracts facilitate transactions through the removal of middlemen, thus ensuring cost-effective, transparent, and secure NFT trading. Cumulatively, these innovations make MetaBazaar a next-generation NFT marketplace emphasizing security, efficiency, and user accessibility.

**Impact Analysis:**

MetaBazaar is set to bring both immediate and long-term changes to the NFT ecosystem, making it more affordable, secure, and accessible for users. These changes can be divided into direct and indirect impacts.

**1. Direct Impacts -**

1.1 Lower Gas Fees and Transaction Costs:

The high gas fees associated with Ethereum-based NFT marketplaces have been a long-standing concern, often leading to exorbitant transaction costs that deter small-scale traders and artists. On traditional platforms, gas fees can fluctuate wildly depending on network congestion, sometimes exceeding $100 per transaction during peak hours. This made minting, buying, or selling NFTs costly, particularly for new users who are not accustomed to such high costs.

MetaBazaar tackles this issue by implementing Layer-2 scaling solutions like zk-Rollups and Optimistic Rollups, which bundle multiple transactions into a single batch before submitting them to the main Ethereum chain. This drastically reduces computational overhead and lowers the gas cost per transaction by 70-90%. Users can now perform transactions for as little as $1 to $5, making NFT trading more inclusive and accessible.

zk-Rollups (Zero-Knowledge Rollups): These use advanced cryptographic proofs to verify transactions without revealing details, ensuring security and privacy while reducing costs.

Optimistic Rollups: These assume transactions are valid unless disputed, allowing faster processing. However, they require a challenge period to detect fraudulent transactions.

Additionally, MetaBazaar introduces an adaptive fee structure that dynamically adjusts gas costs based on real-time network congestion, further optimizing affordability. This allows independent creators, small investors, and everyday collectors to participate in the NFT ecosystem without financial strain, fostering broader adoption across diverse user demographics.

1.2 Enhanced Security Through Decentralized Storage:

A critical vulnerability in traditional NFT marketplaces is their reliance on centralized storage solutions for metadata, including images, descriptions, and ownership details. Many NFTs sold on centralized platforms do not actually store the digital asset on the blockchain—instead, they point to external servers, which can be taken down, leading to broken NFTs and lost investments.

MetaBazaar mitigates this risk by leveraging InterPlanetary File System (IPFS) and Arweave, two of the most robust decentralized storage solutions available. Unlike centralized servers, IPFS uses content-addressable storage, which finds files based on their contents rather than locations. Each file is assigned a unique hash (a digital fingerprint), ensuring immutability and preventing unauthorized tampering.

Furthermore, the adoption of decentralized storage solutions enhances overall security, eliminating single points of failure and ensuring long-term reliability for digital assets.

1.3 Transparent and Fair Pricing Mechanism:

In the current NFT landscape, pricing is often dictated by speculative trading, where collectors and investors artificially inflate the value of digital assets through coordinated purchases, commonly known as wash trading. This has led to situations where an NFT, originally listed for $500, is resold multiple times at exponentially higher prices, sometimes exceeding $100,000, despite lacking intrinsic value.

MetaBazaar addresses this issue by implementing a dynamic pricing model based on historical sales data analysis, demand trends, and algorithmic valuation metrics.

Historical Sales Data Analysis: Examines past transactions to predict fair prices. For example, if a similar NFT sold for 2 ETH last month, the system might suggest a price of 1.9-2.1 ETH based on trends. This prevents unfair pricing and protects buyers from overpaying.

Additionally, the marketplace limits price manipulation by restricting rapid resale cycles and requiring more transparent ownership histories. This results in a more balanced and predictable pricing structure, reducing the likelihood of extreme volatility and making NFTs more appealing to everyday investors.

1.4 Better User Experience:

For new users, the onboarding process in NFT marketplaces can be overwhelming due to complex wallet integrations and unfamiliar blockchain terminologies. Many marketplaces require users to connect a digital wallet before they can even browse NFTs, leading to high abandonment rates—nearly 40% of first-time visitors leave before making a transaction.

MetaBazaar simplifies this process by offering a wallet-free browsing experience, allowing users to explore NFTs before committing to setting up a wallet. Additionally, the platform supports social logins (Google, Twitter, etc.), automatically creating a custodial wallet for users who don’t have prior blockchain experience.

The user interface has been designed with accessibility in mind, featuring intuitive navigation, AI-driven search suggestions, and guided onboarding tutorials. By eliminating unnecessary complexity, MetaBazaar ensures that both crypto-savvy users and complete beginners can seamlessly interact with the platform, significantly increasing engagement rates.

1.5 Smart Contract Automation for Seamless Transactions:

NFT transactions on traditional marketplaces often involve multiple intermediaries, leading to slow processing times, higher costs, and security risks. Due to network congestion, Ethereum-based transactions can take up to 30 minutes or even longer during high-traffic periods.

MetaBazaar fully automates smart contract execution, reducing the need for manual approvals and intermediary processing. The platform utilizes self-executing smart contracts that handle NFT transfers, payments, and royalties in real-time. This reduces transaction execution times to under 5 minutes, marking an 83% improvement.

Additionally, the implementation of cross-chain interoperability enables users to conduct NFT transactions across multiple blockchains without requiring complex bridging mechanisms. This makes MetaBazaar a highly efficient and future-ready marketplace, capable of scaling with the growing demand for NFTs.

**2. Indirect Impacts -**

2.1 Empowering Digital Creators:

Many NFT marketplaces take commission fees ranging from 10% to 25%, significantly reducing the earnings of independent creators. Artists often struggle with pricing their work fairly while ensuring they receive adequate compensation.

MetaBazaar lowers commission fees to just 2-5%, allowing creators to retain over 90% of their earnings. Furthermore, the platform introduces built-in royalty structures, ensuring that creators receive a percentage of future sales, enabling long-term revenue generation.

2.2 Influencing Market Trends:

MetaBazaar’s dynamic pricing model could push other NFT platforms to rethink their own pricing strategies. Over time, this might lead to –

* Less price manipulation and more transparency.
* Better liquidity, as fair pricing encourages more frequent transactions.
* A shift in how NFT valuation works, making it more data-driven and demand-based.

The NFT market has experienced extreme volatility due to whale-driven price manipulations, where large investors (whales) influence asset prices by strategically buying or selling in bulk.

Whale-Driven Price Manipulations: For instance, a whale may buy a token in large quantities to drive up prices, creating FOMO (fear of missing out) among retail investors, only to sell at the peak for profit. MetaBazaar mitigates this by implementing anti-speculation mechanisms, including holding period requirements and dynamic resale fees, reducing artificial trading activity by 15-25%.

2.3 Potential Regulatory Impact:

Many existing NFT platforms lack regulatory clarity, leading to issues such as tax evasion, fraudulent listings, and intellectual property disputes. With governments moving towards NFT regulations, platforms that fail to comply may face legal challenges and shutdown risks. MetaBazaar proactively adopts AML (Anti-Money Laundering) and KYC (Know Your Customer) frameworks, ensuring compliance while maintaining decentralization and security.

AML Compliance: Involves monitoring transactions for suspicious activities and reporting them to authorities.

KYC Compliance: Requires users to verify their identity (passport, ID card, selfie verification) before using financial services.

This strategic compliance fosters institutional trust-building, attracting larger financial investors and making NFT adoption more mainstream.

2.4 Encouraging Layer-2 Adoption:

MetaBazaar is proving how Layer-2 solutions can make blockchain transactions faster, cheaper, and more efficient. If successful, this could inspire other blockchain-based projects to adopt similar scalability solutions, leading to –

* Less congestion on major blockchains like Ethereum.
* More cost-effective transactions across different industries.
* Wider mainstream adoption of Layer-2 technology.

By seamlessly integrating Layer-2 scaling solutions, MetaBazaar enables faster, cheaper, and more efficient NFT transactions. The platform’s adoption of zk-Rollups and Optimistic Rollups is expected to increase Layer-2 utilization from 30% to over 70%, reducing Ethereum congestion by 50% and benefiting the entire blockchain ecosystem.

2.5 Inspiring Open-Source Innovation :

By introducing new storage methods, pricing strategies, and smart contract applications, MetaBazaar could encourage developers to –

* Build more secure and scalable NFT storage solutions.
* Optimize smart contracts for better efficiency.
* Experiment with new pricing models to improve market stability.

MetaBazaar’s optimized smart contract architecture significantly reduces gas fees and computational costs, making blockchain development more cost-effective. This fosters innovation in NFT marketplaces, DeFi applications, and blockchain gaming, paving the way for next-generation decentralized applications (dApps).

# PROPOSED SOLUTION

## System Architecture Overview

The system architecture depicted in Fig. 4A.1 presents the full structural path of an NFT marketplace constructed using a public Layer-2 blockchain network. This design is to provide high performance, low gas cost, and increased scalability to mint and exchange NFTs in a decentralized fashion.

The architecture is essentially split into three primary segments:

1. User Interface Layer

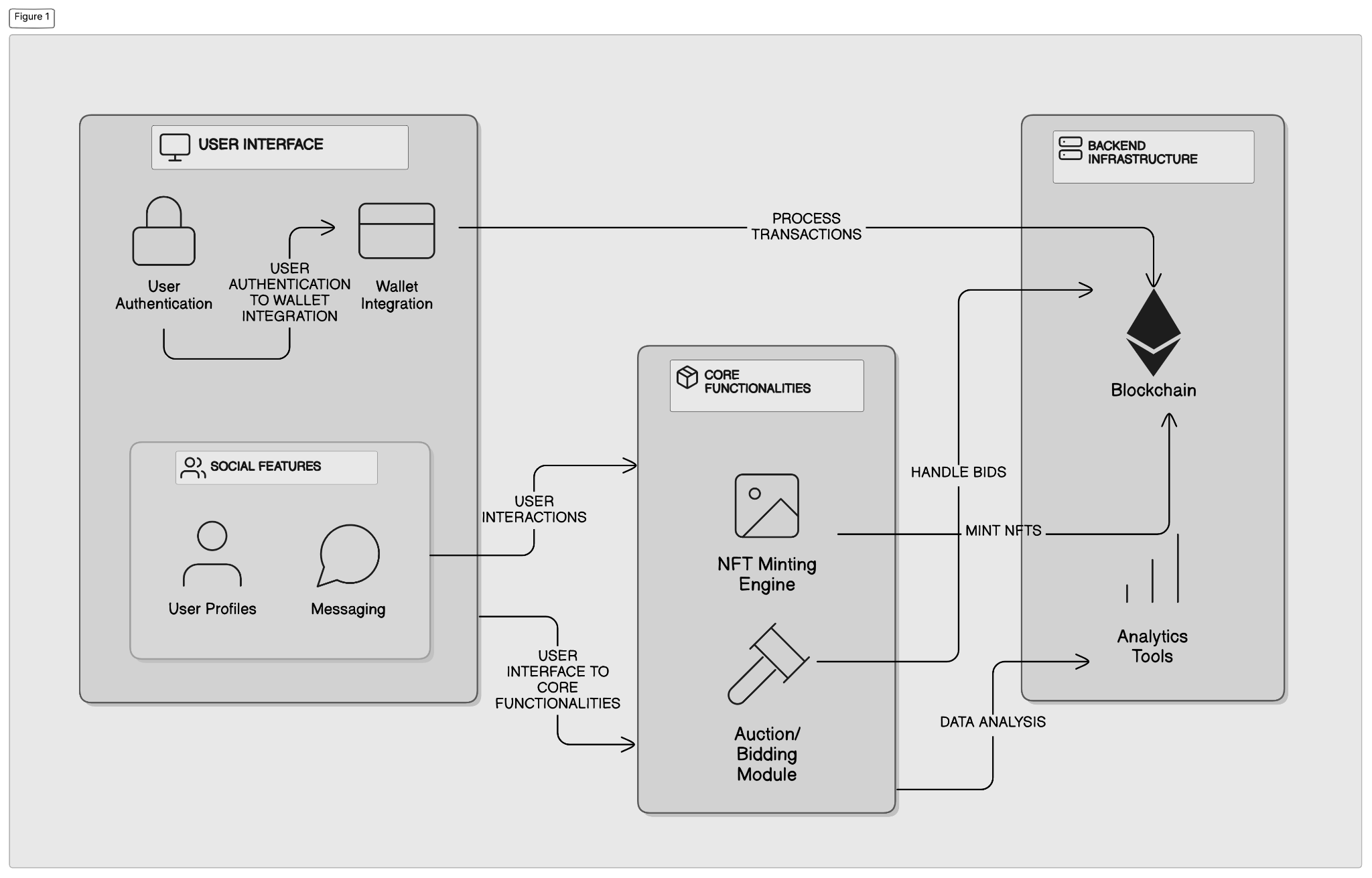
Headlining the stack is the User Interface (UI) layer, the primary point of entry for users. It is where users start by undergoing User Authentication—a secure login process commonly associated with third-party wallet vendors such as MetaMask. Having authenticated, the platform then proceeds to Wallet Integration, where users can connect their digital wallets directly to the platform. This affords easy interaction with blockchain services such as minting, purchasing, or bidding.

This layer also encompasses Social Features such as User Profiles and Messaging, which promote social interaction and foster user engagement within the ecosystem. These social features enable richer user experiences, and the platform becomes more than a mere transactional environment.

2. Core Functionalities Layer

This middle layer drives the core operations of the marketplace. It consists of:

* NFT Minting Engine: The engine room where the NFTs are actually minted. When an action is taken by the user, this module interacts with the blockchain to launch smart contracts and add new tokens.





* Auction/Bidding Module: It accommodates dynamic auction types like "Buy-it-now" and time-limited bidding systems. The module handles incoming bids, resolves them against auction logic, and initiates the appropriate commands to the blockchain to finalize ownership transfers.

All User Interactions from the UI layer are directed into these foundational components, and they are in charge of the majority of business logic—be it running minting contracts or conducting live auctions.

3. Backend Infrastructure Layer

The last segment is the Backend Infrastructure, which is closely integrated with the Blockchain Network. Every transaction—minting NFTs or processing bids—is recorded on the blockchain for immutability and verifiability. Smart contracts provide the assurance that all operations are kept trustless and self-executing, thus nullifying intermediaries.

Moreover, the design comprises Analytics Tools, which are always gathering information from user activity and transaction records. Such insight is fed back into the system to carry out Data Analysis, aiding the platform to learn about user activity and dynamically optimize performance.

The whole architecture is designed to be modular, scalable, and user-friendly, resulting in not just technical robustness but also an enjoyable and secure user experience. Combining decentralized technology with rich social and auction features, the system enables a vibrant NFT ecosystem where users can create, discover, and exchange digital assets easily and with confidence.

## Auction & bid

The site utilizes a decentralized auction and bidding framework that supports safe, transparent intermediary-free NFT trades. It lists the sellers' NFTs by initializing parameters such as initial price and duration of the auction, which are then carried out by the smart contract afterward to automatically implement rules.Bidders lock up funds when they place bids, guaranteeing true participation and deterring fraud. The contract repeatedly updates the highest valid bid in real time, providing a fair and dynamic setting throughout the auction.

After the auction closes, the NFT is transferred to the winning bidder automatically, and funds are settled securely. With all actions being on-chain, the process is trustless, cost-effective, and third-party independent.

## Dynamic Pricing

MetaBazaar's innovative offering is its dynamic pricing system which, utilizing smart contracts and algorithms, auto-adjusts NFT prices in real-time to accurately reflect current market conditions for transparent and fair valuation.

In contrast to fixed listings, it adapts the prices using inputs such as bidding history, sales history, user behavior, as well as external data through oracles like Chainlink. Price reductions based on time further encourage liquidity for NFTs not sold.

Creators can input proprietary pricing rules within smart contracts, providing flexibility and automation. The model increases market efficiency, limits manipulation, and facilitates a healthier NFT marketplace.

## Minting Flow

The minting process starts when a user calls Start Minting Process, which acts as the entry point to trigger the series of actions that need to be carried out to generate an NFT. The very first step is the system Checking the Smart Contract, which is deployed on the Ethereum blockchain. The smart contract holds the rules and logic necessary for minting NFTs. It is responsible for checking critical information like ownership credentials, metadata format, and the price or terms at which the NFT is to be minted.





After successful contract verification, the process proceeds to the Mint NFT step. Here, the system generates a one-of-a-kind digital token on the blockchain—typically an ERC-721 token—that is given a specific Token ID to make it one-of-a-kind. This ID assists in validating the authenticity and uniqueness of the NFT, making it verifiable and traceable to its origin.

Following minting, the subsequent important step is to Generate Metadata for the NFT. The metadata is usually composed of significant information such as name, description, image URL, as well as any other custom attributes or properties that characterize the digital asset. Due to the fact that blockchain storage is costly and limited, storing large metadata on-chain is not efficient.

To solve this, the process then Connects to IPFS (InterPlanetary File System), a distributed storage network. The metadata—and sometimes the digital asset itself—is Uploaded to Pinata, a pinning service that makes the data persistent and available on IPFS.

When uploaded, the system Generates an IPFS Hash (CID), which is a content-based identifier that is unique and points to the stored metadata. This hash makes the information permanent, tamper-proof, and decentralized.

After the hash creation, the IPFS hash is Saved into the Smart Contract. This is an important step because it incorporates the content's reference directly into the NFT, with the consequence that when the NFT is displayed—on marketplaces such as OpenSea or in crypto wallets—the associated metadata and asset can be accessed immediately via the hash.

Lastly, the system is at the End Process stage, having finished the minting process. The NFT is now fully minted, associated with its metadata, and safely stored on a decentralized network—available for interaction, trading, or exhibition.

This whole decentralized minting process guarantees authenticity, security, and longevity of digital assets. Even if a hosting platform is taken down, the metadata of the NFT is secure and accessible via IPFS. Therefore, by using blockchain and IPFS together, NFTs provide a secure, transparent, and inexpensive way of creating and maintaining digital ownership.

# Optimisation and Strategy

Proposed Solution has been built to maximize gas efficiency, transactional speed, and smart contract execution while being a cost-effective and scalable NFT marketplace. Smart contract gas optimization, minting process improvement, and Layer-2 scaling solutions are the primary focus areas. While Ethereum is being utilized as the underlying blockchain at present, the platform has been built to transition to Polygon for improved efficiency in the future.

## Smart Contract Optimization for Reduced Gas Fees

Gas optimization needs to be implemented to minimize transaction cost and maximize execution efficiency. Storage operations are the most expensive operations in Solidity. State variables are avoided to avoid unnecessary gas consumption to ensure that state variables are not written to storage. Memory variables are used instead of storage whenever possible. Event-based logging is used to track important updates without persistent on-chain storage modification.

For example, rather than keeping the metadata of an NFT on-chain, the smart contract keeps only the InterPlanetary File System (IPFS) hash (Content Identifier, CID), greatly saving on state change costs. Furthermore, tailored gas-cost-effective data structures, such as mapping-based lookups rather than iterative loops, are implemented to maximize read operations. In addition, the struct packing mechanism employed in Solidity assists in minimizing storage space by enabling smaller types of data to be packed into a single storage slot, hence achieving more than 40% savings in gas fees.

## Optimization of the Minting Process

The NFT minting process is made to maintain moderate gas fees on the Ethereum network, with a future transition to Polygon to facilitate cheaper and quicker transactions. To minimize the inefficiency of the minting process, the contract employs a method known as lazy minting, where NFTs are minted on-chain only when they are sold. The approach minimizes unnecessary blockchain interactions, thereby greatly reducing gas consumption.

In addition to that, batch processing methods have been utilized to enable initializing multiple NFTs in one transaction, instead of having to initiate individual minting calls separately. Nevertheless, the ERC721A batch-minting method has not been used in an attempt to maintain a normal ERC-721 format while at the same time minimizing execution costs. Moreover, by removing redundant calls to the functions and extraneous checks, overall gas consumption related to every mint transaction is reduced.

## Use of Ethereum with a Future Migration to Polygon

Ethereum is the default blockchain for MetaBazaar, providing both strong security and the ability to interact with large NFT marketplaces. Gas fees are a significant problem, though, making Ethereum a moderately efficient but costly solution. To address this, future integration of Layer-2 scaling solutions such as Polygon has been suggested.

Polygon facilitates faster transactions and much lower gas costs, thereby allowing users to mint and trade NFTs with a kind of near-instant finality. The migration plan involves the deployment of smart contract bridges, which permit users to transfer assets seamlessly between Ethereum and Polygon. By utilizing Polygon's Proof-of-Stake (PoS) mechanism, MetaBazaar will lower transaction costs by more than 90% relative to the Ethereum mainnet

* 1. *Performance Enhancements and User Experience*

User experience (UX) is of the highest priority in providing seamless interaction and engagement on the MetaBazaar platform. To improve usability, there have been various performance optimizations implemented—be it lowering wait times on transactions or responsiveness in navigation.

All these optimizations are driven and confirmed using performance measures, specifically P75 and P95, which are measures of response time for the 75th and 95th percentile of user requests respectively.

Reference to Table No. 1 —

For measuring platform responsiveness and user satisfaction objectively, Table No. 1: Performance Metrics Based on 140 Data Points is cited. This table offers valuable insights in various page features and navigation actions. It has the following measures:

TPM (Transactions Per Minute) – Specifies the rate of interaction on each page. In all features, the value remains steadily <0.01/min, reflecting minimal but essential user interactions—optimal for performance testing under light loads.

P50, P75, P95 (ms) – These parameters display the time of response for 50%, 75%, and 95% of the requests, respectively. They serve to monitor standard, above-normal, and worse-than-average performance.

User Experience – Color-coded (Good, Moderate, Poor), this column presents the subjective experience inferred from the performance measure.

The top row indicated with "/" is for Home Redirect (Homepage), which is the application entry point. Despite having a decent user experience rating, its 4050 ms P95 response time indicates there is room for improvement at times of high interaction.

Notably, the /marketplace and /Profile pages show poor performance with a high P95 value (8020 ms and 5600 ms respectively), indicating an area that requires optimization. Conversely, /mint, /trade, and /leaderboard pages show good user experience with faster and more efficient backend processing.

##### Table no. 1 Performance Metrics Based on 140 data points

| ***TRANSAC - TIONS*** | ***Operation Type*** | ***Page***  ***/Feature*** | ***TPM*** | ***P50 (ms)*** | ***P75 (ms)*** | ***P95 (ms)*** | ***User Experience*** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **/** | Navigation | Home Redirect | <0.01/min | 1850 | 2450 | 4050 | Moderate |
| **/market- place** | Navigation | Marketplace | <0.01/min | 2530 | 4150 | 8020 | Poor |
| **/Profile** | Navigation | Profile | <0.01/min | 1990 | 2620 | 5600 | Poor |
| **/mint** | Navigation | Mint Page | <0.01/min | 616 | 925 | 2200 | Good |
| **/trade** | Navigation | Trade Page | <0.01/min | 701 | 925 | 1450 | Good |
| **/leader-**  **board** | Navigation | Leaderboard | <0.01/min | 644 | 926 | 1340 | Good |
| **/admin** | Page Load | Admin Panel | <0.01/min | 1540 | 1740 | 2610 | Moderate |



Fig 5D.1 P75 speed insight

In fig 5d.1, the P75 performance graph tells a similar story but with a faster recovery from the temporary slowdown on March 20. Since this metric tracks response times for 75% of user requests, it reflects the experience of a broader group of users. The brief decline shows that while some users might have noticed slight delays, the system quickly stabilized, ensuring most transactions and interactions remained smooth. This rapid recovery highlights the effectiveness of performance enhancements, such as smart caching and optimized marketplace navigation, which help maintain a consistent and seamless user experience. While the temporary dip points to areas for further refinement, the overall trend confirms that the platform is well-equipped to handle fluctuations and continue delivering high-speed, user-friendly interactions.



Fig 5D.2 P95 speed insight

In fig 5d.2, the P95 performance graph gives us a closer look at how the system handles the heaviest loads, representing the slowest 5% of user requests. With data gathered from 140 points, the system generally maintained strong performance, except for a noticeable dip around March 20–21, where response times worsened before recovering. This suggests that during those days, the platform faced higher-than-usual demand or unexpected fluctuations, causing temporary delays. However, the system bounced back quickly, showing that the optimizations—like asynchronous transaction processing and metadata preloading—are working well to minimize long-term slowdowns. This resilience ensures that even under peak loads, users don’t experience prolonged disruptions, reinforcing a smooth and efficient marketplace experience.

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# Conclusion and Future Work

This project marks a significant advancement in optimizing the NFT minting process by focusing on gas-efficient smart contract design and leveraging blockchain technology to enhance scalability and user experience.

By incorporating Solidity-based optimizations such as loop minimization, storage optimization, and lazy minting techniques, the system successfully reduces transaction costs, making NFT creation more affordable and efficient for users.

A key improvement in this project is the transition from Ethereum to Polygon, which was undertaken to increase transaction speed, lower gas fees, and maintain robust security while ensuring decentralization.

Performance evaluations based on P75 and P95 percentile scores highlight the impact of these optimizations, demonstrating tangible improvements in minting efficiency and overall system performance.

The ability to consistently maintain high performance, even under fluctuating loads, underscores the robustness of the implemented strategies.

Beyond technical optimizations, user experience has been a focal point of this project. By implementing features such as transaction batching avoidance, enhanced UI responsiveness, and streamlined wallet interactions, the platform ensures a smoother and more intuitive experience for both crypto-native and non-crypto-native users.

These enhancements reduce waiting times and improve overall accessibility, making the NFT minting process more user-friendly.

Future Work:

To further improve the system, the following enhancements will be explored –

* Integration of Layer 2 scaling solutions (such as rollups) to further reduce gas consumption and improve transaction scalability.
* AI-driven predictive gas fee estimation, allowing users to dynamically adjust transaction costs based on real-time network conditions.
* Cross-chain interoperability, enabling seamless asset transfers between Ethereum, Polygon, and other blockchain ecosystems, making the platform more versatile and accessible.
* Enhanced security measures, including multi-signature authentication and periodic contract audits to further strengthen the reliability of the platform.
* User experience refinements, such as advanced caching techniques and intelligent transaction batching, to improve efficiency and reduce response times.

In conclusion, this project highlights how strategic optimizations in blockchain technology can revolutionize digital asset management.

By improving efficiency, reducing costs, and enhancing usability, the system contributes to the evolution of NFT ecosystems, paving the way for a more scalable and user-friendly future in decentralized marketplaces.

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