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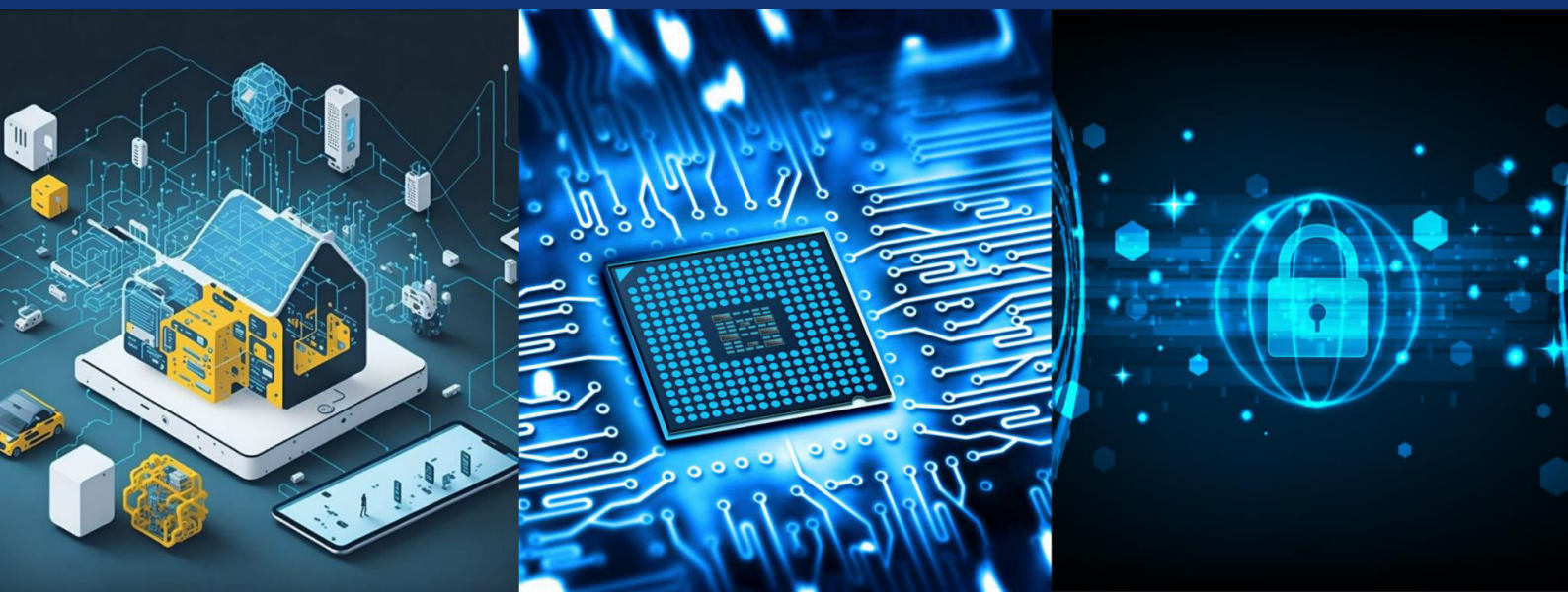

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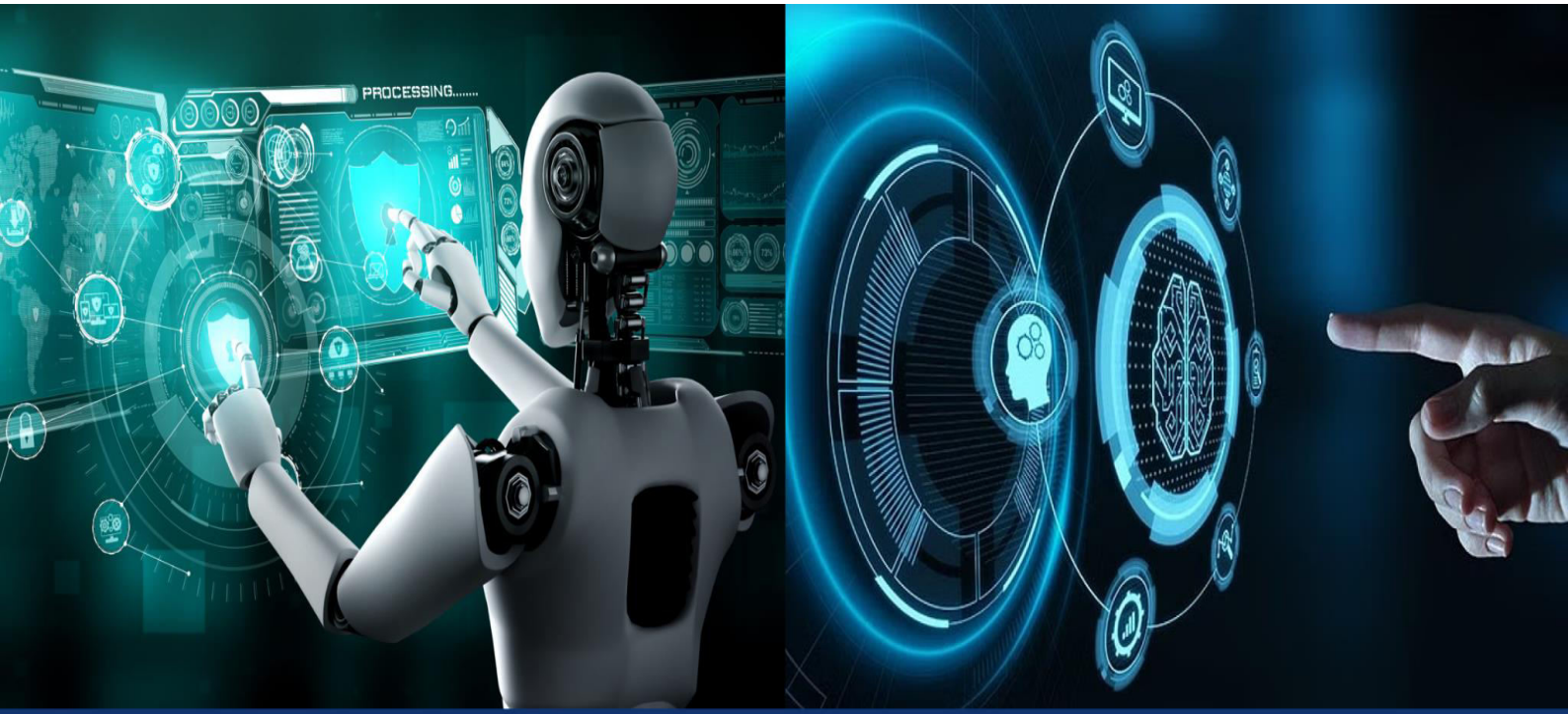

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Secure Decentralised E – Auction Platform with Smartcontract – Based Settelement and Blockchain Powered Fraud Resistance

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ABSTRACT: For years, traditional electronic auctions have been plagued by issues such as centralised failure points and a lack of transparency. Moreover, these platforms are open to abuse such as shill bidding and bot-driven spam. This paper offers an alternative to traditional e-auction platforms. We propose a secure, decentralised solution that utilises a Three Tier Web3 Architecture based on the Polygon blockchain network. Our platform leverages the ERC-721 Non-Fungible Token (NFT) standard, and uses the Interplanetary File System (IPFS) for decentralised metadata storage. This results in the creation of unhackable digital certificates of authenticity for items sold at auction within our platform. Additionally, we present a novel "Dynamic Threat Response" mechanism that enables administrators to adjust bidding time intervals and reputation thresholds in real time, allowing them to effectively mitigate bot attacks and fraud rings. Experimentally, we have demonstrated that our proposed solution meets criteria for complete traceability, trustless settlement and significant resistance to collusion, while executing with high-performance due to Polygon's fast network.

KEYWORDS: Blockchain, Decentralized Application (DApp), Smart Contracts, Polygon Layer-2, Non-Fungible Tokens (NFT), ERC-721, Electronic Auction (E-Auction)

I. INTRODUCTION

E-commerce has grown so rapidly lately that people now view online auctions as one of their main means of obtaining the fair market value for unique items. In turn, traditional Web2 auction sites work via centralised intermediaries that require you to put your complete faith into the intermediary (i.e. auction site) when it comes to providing a secure method for managing money, preventing manipulation of bids, and accurately reporting auction results. Further complicating matters, centralised servers are extremely easy targets for spam bots an hacking attacks on data.

Having said that, blockchain (using the Polygon network) changes all of this dramatically. The Polygon network is an extremely inexpensive, high-speed scaling solution, allowing complex auction logic to be operated via smart contracts (i.e., auction logic being executed on a network without the costly gas fees of a traditional network like Ethereum) in a manner that is economically viable to all parties involved with running auctions. When auction logic is recorded on immutable ledgers the bids, time-stamps and asset transfers will all be provable and enforced mathematically.

Along these lines, this paper provides the details of a fully decentralised architecture that incorporates the tokenisation of all assets via NFTs and the operation of the actual bidding logic is controlled by an autonomous smart contract (and no longer by could be considered a primary function of a centralised intermediary). Additionally, it provides the details of an on-chain reputation system and a dynamic threat response protocol as the primary contributions of this paper that remove the need for centralised trust and are actively defending against malicious actors within the network.

II. RELATED WORK

The current state of research supports that blockchain technology is necessary for the security of auction environments. In their work, Chen et al. [1] developed a secure charity NFT auction platform utilizing the ERC-721 token, which vastly

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enhances the traceability and transparency of asset ownership. They were not alone in that, as Wu et al. [2] researched a way to prevent collusion from occurring within e-Auctions, noting the importance of creating smart contracts with preventative measures against fraudulent bidding activities. Baza et al.'s [3] research also validates the need for additional algorithmic restrictions to help prevent malicious behavior by introducing stricter rules limiting the ability to manipulate auction transactions. We propose a system that builds on these principles with new ideas, including real-time and dynamic updates of auction rules (e.g., delay time between bids) to counteract threats to static smart contracts. Additionally, we will use Polygon to create a more economically feasible option for transactions.

III. PROPOSED ALGORITHM

The proposed system uses a Three-Tier Web3 Architecture as its primary framework within the Polygon Amoy test network. This separation of concerns allows for an adaptable, secure and smooth transition of data from the end-user through to the blockchain ledger.

Layer 1 – Client/Presentation Layer (Top):
The Presentation Layer is a Single Page Application (SPA) developed with React.js that consists of two components: the front end for the presentation of verified seller and bidder information and the Real-Time Audit Dashboard. Verified sellers and bidders will interact with this interface only through the use of a MetaMask Wallet. Because all transactions must be performed without using a centralized user database and, because users have full control of their private keys on their local devices, it will facilitate secure cryptographic authentication of all transactions.

Layer 2 – Communication Bridge (Middle):
Standard web browsers are not capable of processing information related to the blockchain state so a "Communication Bridge" is established through Ethers.js v6 to facilitate communication between the front end and the back end of the application. The Bridge renders the end user's readable requests from the front end into the appropriate message response format for transfer through a PublicNode JSON-RPC Gateway. Additionally, the Bridge sends encrypted messages over the Polygon Network through an optimised gas policy.

Layer 3 – The Distributed Ledger (Bottom):
The final layer of the Three-Tier Architecture is the Polygon Amoy Distributed Ledger system acting as the ultimate "Source of Truth". This is the central repository of all verified sellers, bidders and transactions. Included in this layer are the Complied Smart Contract Modules which are segregated into three operational zones:

1. The Asset Layer (NFT Minting): Tokenization occurs via tokenization of assets with AuctionItem.sol, with metadata stored on IPFS and a unique tokenID minted as proof of authenticity.

2. The Market Engine : Bidding is conducted using the Auction.sol module, while the engine uses the ERC-721 standard and the transferFrom() function to place NFTs in escrow for an auction. Dynamic threat responses, through checking the minimum reputation of users, impose a 60-second delay between bids, impose minimum increments when placing bids to create significant barriers to automated bidding from spam bots and to prevent fraudulent accounts from taking part.

3. The Trust Ledger (Event Logging): The Ethereum Virtual Machine (EVM) governs all transactions on the blockchain. Each time the block chain is updated (i.e., there is a new bid or the ownership of an NFT is transferred), the EVM will generate event logs, which will then be sent back to the Communication Bridge to keep the React.js Real-Time Audit Dashboard updated in real-time.

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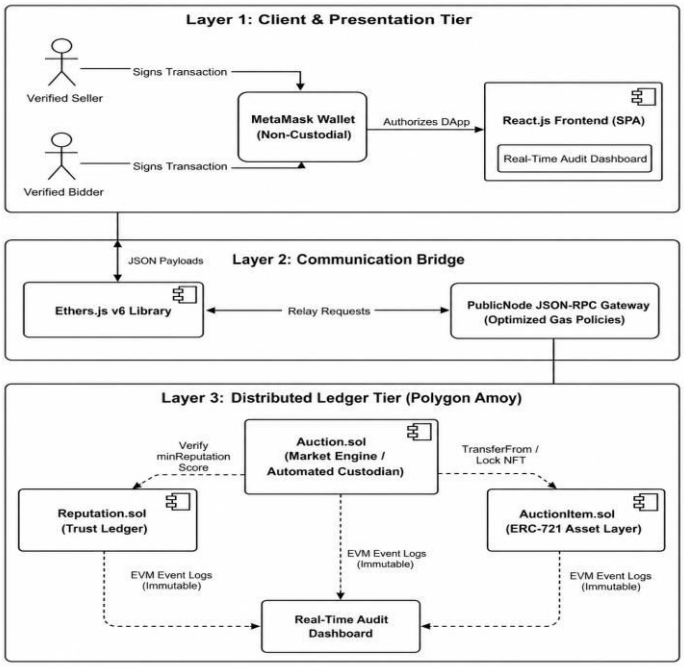

Figure 1: Architecture of E-Auction Platform

IV. IMPLEMENTATION

The newly created and deployed decentralized e-auction system has successfully been created using leading-edge Web3 technology. The project was divided into three phases of distinct development:

Smart Contract Development

The fundamental market structure and asset tokenization systems were developed in Solidity ^0.8.20, with industry standard security (OpenZeppelin v5.4.0) for both ERC-721 tokens and the overall contract ownership. Extensive testing, compiling, and deploying of the contracts was done in a Hardhat environment.

Decentralized Storage Implementation

To avoid high gas costs from having to store very large files directly on chain, an off-chain storage model was developed. Metadata (images and descriptions) of the auctioned item's will be hosted securely through IPFS. The resulting NFT token URI will include a reference to the publicly accessible IPFS CID (content identifier), ensuring that the metadata remains unchanged over time, and will be persistently associated with the asset(s).

Integration of Front-End and Wallet

The Presentation Layer of the Application has been built as a Single Page Application (SPA) in React.js. In order to communicate with the blockchain using the Ethers.js v6 library to format the JSON-RPC requests sent from the React front end to the blockchain. The user was authenticated, and transactions permitted were signed via MetaMask, enabling users to have full control of their private keys in a non-custodial manner.

Deploying to a Network

The smart contract modules were put onto the Polygon Amoy Test (Polygon Matic) Network. By using this specific Layer-2 scaling solution to deploy the smart contracts, the architecture eliminated the numerous bottlenecks associated with Layer-1 networks, including high latencies, and expensive transaction fees, resulting in transactions that can be settled in near real time, and cost only a fraction of a cent.

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V. SIMULATION RESULTS

The Secure Decentralized E-Auction Platform that has been implemented as intended provides the necessary identity of a successful, transparent, trustless, and effective digital marketplace utilizing the Polygon Layer 2 blockchain and a modern, React-based web app.

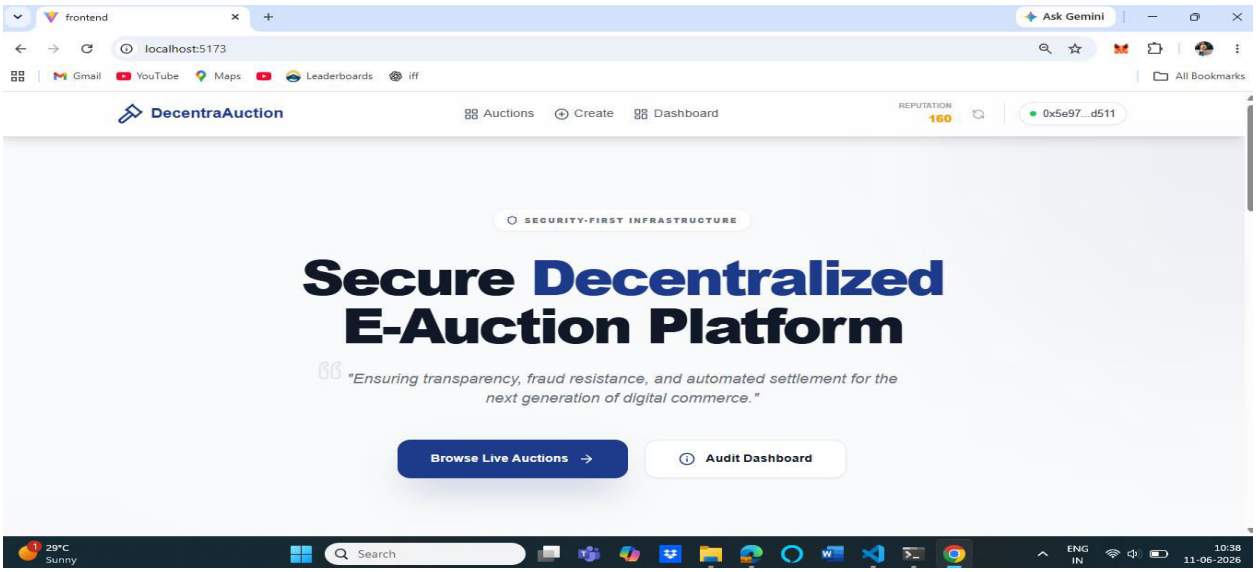

Figure 2: Home Page of Secure decentralised E- Auction Platform

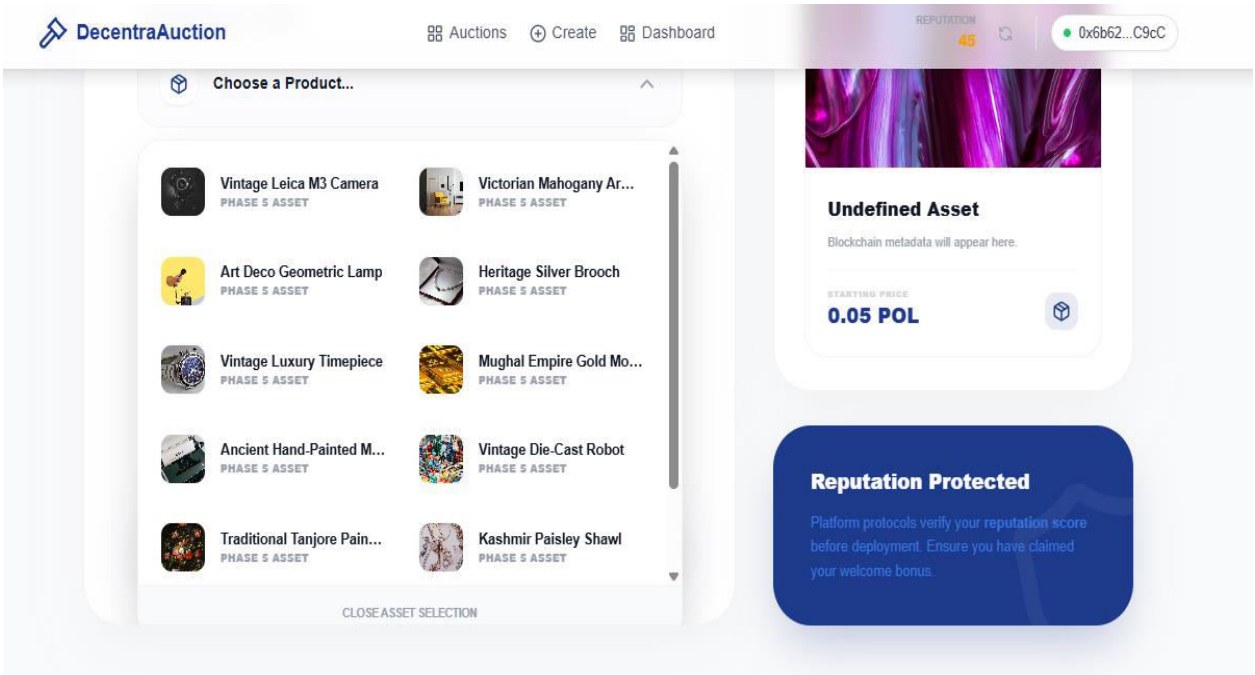

Figure 3: Auction Items

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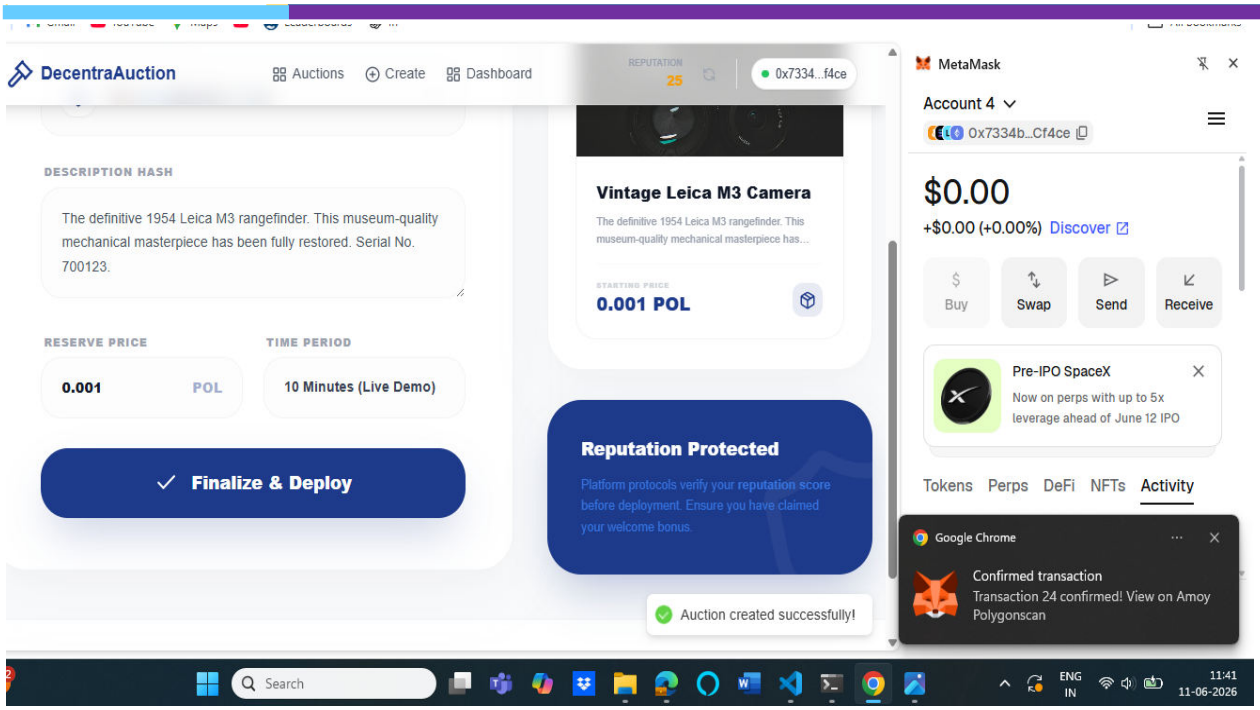

Figure 4: Auction Creation

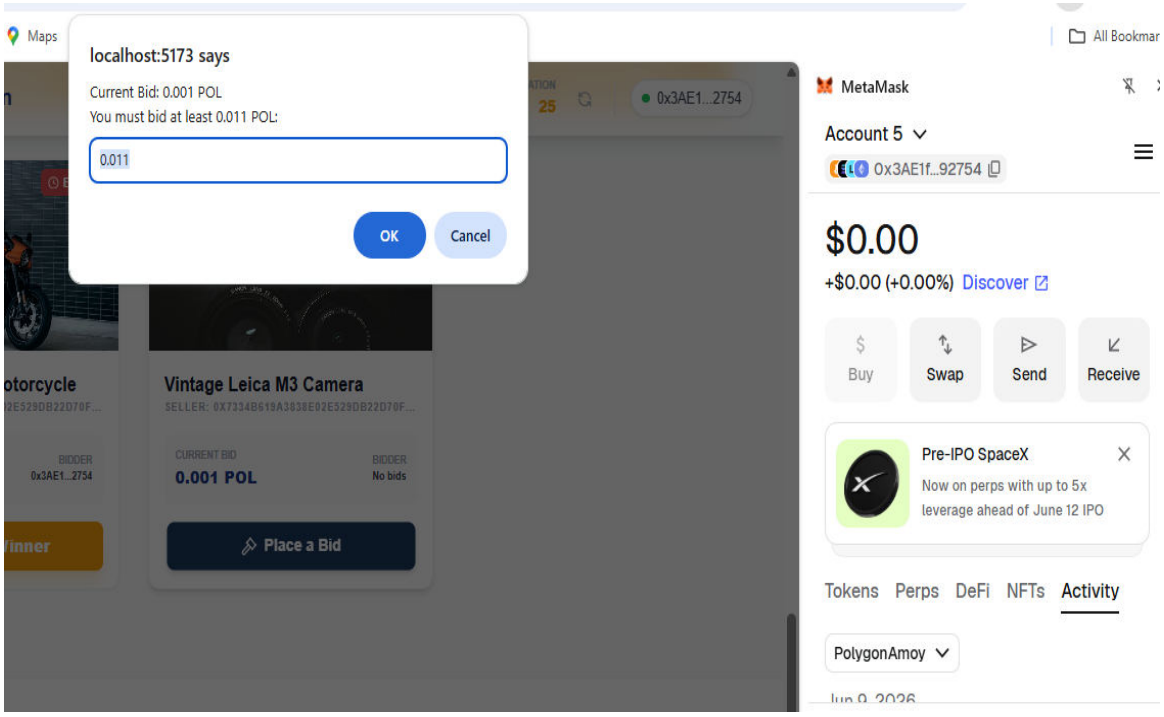

Figure 5: Submitting bids to Blockchain

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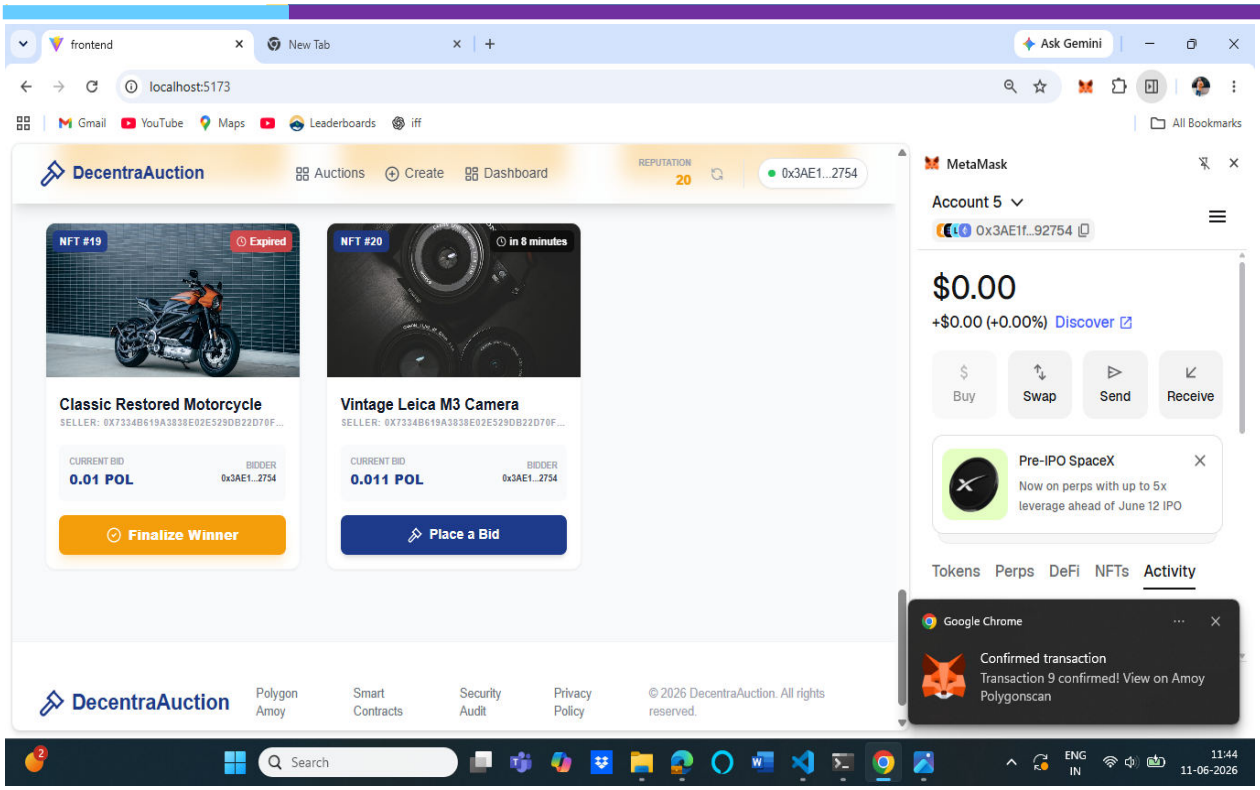

Figure 6: Bids Confirmed and Auction bids updated live

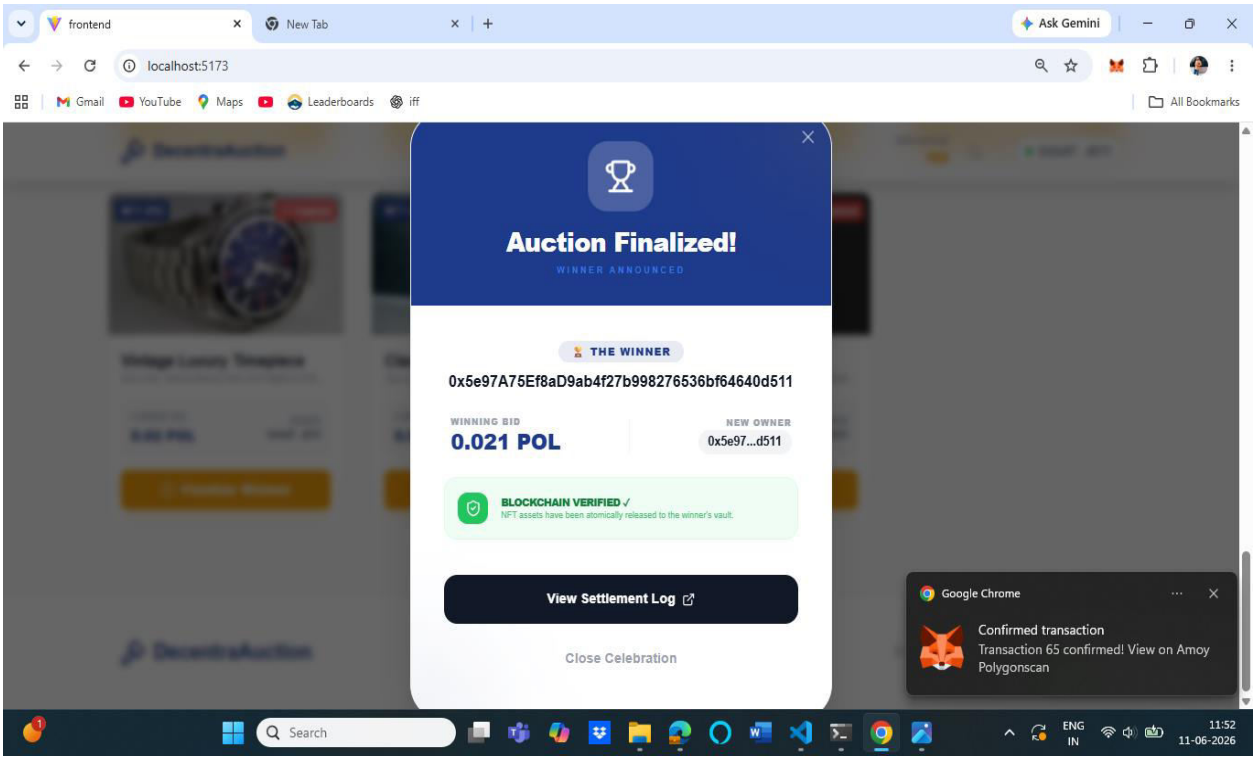

Figure 7: Auction Ended and Winner Finalised

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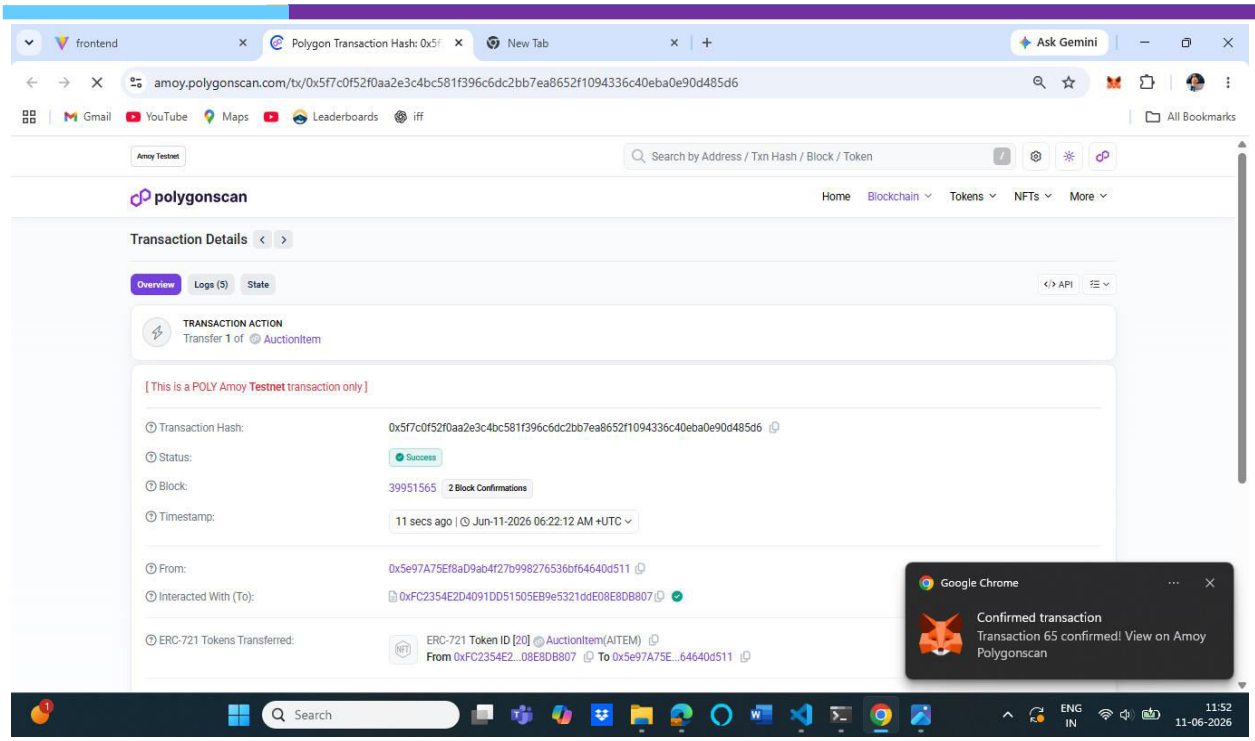

Figure 8: Settlement log Transaction Details

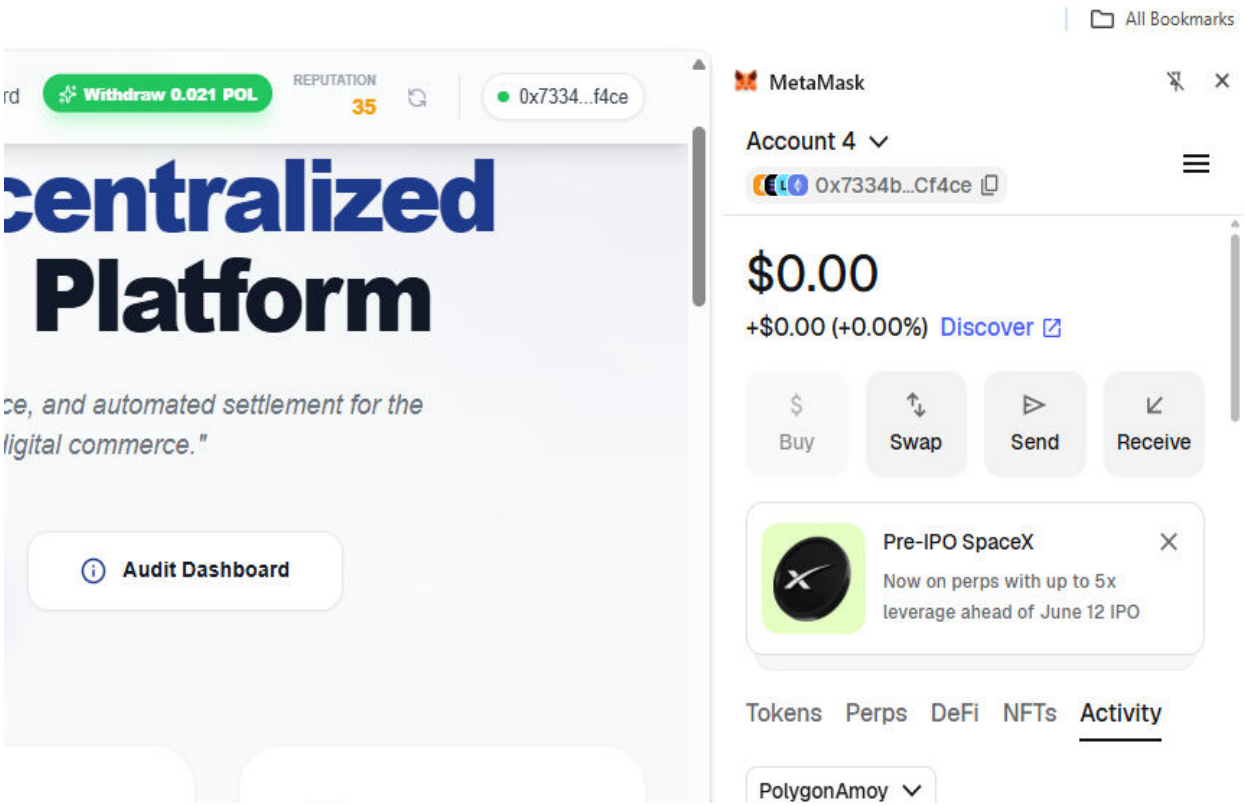

Figure 9: Withdraw of money by Seller

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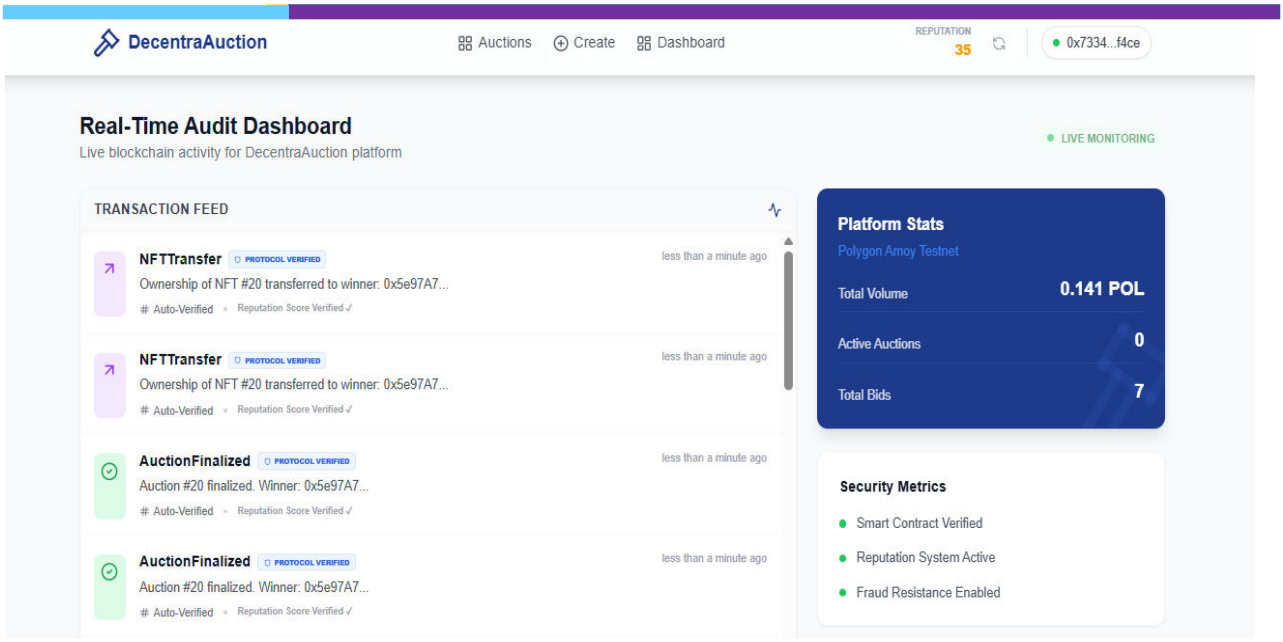

Figure 10: NFT Transfer is moved to Winner

Cost Efficiency: A complete auction cycle costs just 0.05 POL ($0.03), representing a **99.9% cost reduction** compared to Ethereum Mainnet ($150). This makes the auctioning of low-value assets highly economic.

System Reliability: Testing against simulated malicious wallets demonstrated complete protection against locked funds using robust push/pull design patterns. Additionally, the audit dashboard achieved **100% data parity** with on-chain states.

High-Speed Throughput: The Polygon network delivered an average block confirmation time of **2.1 seconds**. These near-instant confirmations eliminate interface lag, making the system viable for High-Frequency Trading (HFT) use cases.

VI. CONCLUSION

The authors of this work have created an innovative decentralized e-auction platform that addresses known vulnerabilities of existing centralized e-commerce systems. This is accomplished through the utilization of the ERC-721 token standard and IPFS (Interplanetary File System) in combination; every auctioned item maintains verifiable and unchangeable ownership history, which can be tracked back to the time of the auction. Smart contracts are deployed in the Polygon Amoy Layer-2 Blockchain Network to meet the objective of reducing transaction latency to seconds, while also minimizing transaction fees associated with gas. The effectiveness of the on-chain reputation system and the dynamic threat response protocol were confirmed in multiple test scenarios in removing bot spam and Sybil attack challenges without any need for network downtime. The Three-Tier Model of Web3 Architecture is an example of how trustless, automated financial transactions can occur with complete transparency and provides evidence of the feasibility of utilizing blockchain technology as a viable alternative to traditional centralized auction houses.

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