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Eliminating Intermediaries in E-Commerce: A Decentralized Marketplace Prototype using Ethereum Virtual Machine and Interplanetary File System

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ABSTRACT

Electronic commerce (e-commerce) has revolutionized the way businesses operate worldwide. This technology has enabled online trading and economic services across various industries. Third-party marketplaces, known for their trusted intermediation and secure online transaction services to anonymous internet traders, are among the drivers of e-commerce. These centralized corporations charge a fee for their services, but online trading is not immune to various crimes such as identity theft, non-payment, delayed service delivery, and other attendant risks. To mitigate these problems, this research proposes a prototype system that utilizes blockchain technology to achieve decentralization in internet trade. The system's proof-of-concept utilizes the Ethereum Virtual Machine (EVM) and Interplanetary File System (IPFS). The proposed system can work with EVM-compatible blockchains such as Tron, the Binance Smart Chain, Matic network, Tomo chain, and Rootstock (RSK) network. The study demonstrates the potential of blockchain technology in e-commerce by providing a decentralized marketplace that is free from centralized control. By removing intermediaries, the proposed system eliminates the need for trust in third-party marketplaces, which in turn reduces transaction costs, and ensures transparency and accountability. The findings of this research highlight the practicality of using blockchain technology in e-commerce, and how it can significantly reduce transaction costs, improve security, and promote decentralization.

1. INTRODUCTION

E-commerce has revolutionized the way businesses operate, enabling physical goods to be traded online between anonymous internet users. However, centralized or third-party marketplaces, which facilitate these transactions, have left online trading vulnerable to crimes and scams, dampening consumer and seller confidence (Jung et al., 2022; Solowey and Schulp, 2023). The Federal Bureau of Investigation's (FBI) 2022 internet crime report shows that internet retail scams are one of the top categories of crime recorded in the United States, with estimated losses of $10 billion in the year 2022 (FBI, 2022). While centralized marketplaces have employed several measures to mitigate these risks, such as acting as arbitrators, implementing escrow services, and reputation systems, these have limitations and can still leave consumers and sellers open to fraud.

One promising technology that can address some of the challenges of centralized marketplaces is blockchain, which is a decentralized digital ledger that records transactions across a network of computers. Blockchain technology has enabled the development of smart contracts, which are automated contracts saved and executed on blockchain nodes, creating secure and decentralized applications. This technology has found vast applications in various areas such as finance, medicine, and agriculture. In this paper, we explore the use of blockchain technology to create a decentralized marketplace using the Ethereum Virtual Machine (EVM) and Interplanetary File System (IPFS).

A decentralized marketplace provides a platform where vendors can sell their products or services to a curated customer base, without the need for a central intermediary. Centralized marketplaces such as Amazon and eBay provide more user security from retail fraud than other anonymous, small marketplaces (Kabi and Franqueira, 2019). However, these centralized corporations store a vast quantity of user data that can be monetized or sold to third parties (Kirkpatrick, 2021). In contrast, a decentralized marketplace, built on the EVM and IPFS, offers more privacy, security, and transparency to online traders. EVM is a blockchain-based decentralized computing platform that executes smart contracts, while IPFS is a peer-to-peer file-sharing protocol that enables efficient and decentralized file storage and retrieval. The combination of these technologies can create a decentralized marketplace that is more secure, efficient, and transparent than centralized marketplaces.

Decentralized marketplaces on the blockchain are gaining momentum as a new paradigm for conducting transactions online. The analysis of Subramanian's (2017) regarding the benefits of adopting blockchain-based marketplaces is a fascinating read. He identifies cost-effectiveness, rapid transaction time, improved data privacy, and user security as some of the key advantages of this novel approach. Furthermore, he considers the possibility of partial decentralization of physical products, which could prove challenging due to the complexities of offering decentralized Business-to-Business (B2B) systems. Despite the benefits of decentralization over firmed controlled marketplaces, there is still a need for proof-of-concept systems.

Khajvandi, (2017) presented a compelling proposition for smart market protocols, offering a marketplace for self-governing agents to buy and sell data and microservices, precisely with the intent of using Internet of Things technology (IoT). However, their work is limited in scope and only addresses a specific area of the market. Nasonov *et al.* (2018) proposed a big data program that corporations can use to trade Big Data sets. Such a program would deliver an invaluable tool for corporations to enhance their business by utilizing the knowledge garnered from such data sets. Unfortunately, their work was incomplete as the real system was not implemented to validate their design. Eskandari *et al.* (2017) studied the feasibility of utilizing smart contracts to accomplish a derivative market that makes the work of an intermediate agent redundant is a thought-provoking read. They highlighted gaps in the present infrastructure, including the lack of decentralized data feeds. Decentralized data feeds may not only cause likely vulnerabilities in the event that centralized data feeds are tampered with but may also prevent the development of protected and self-governing derivative markets. However, their work could be modified to leverage the native token of the Ethereum blockchain network, Ether, as the currency for buying and selling commodities on the marketplace, thus eliminating the need for an external price feed. Xu *et al.* (2018) proposed a decentralized social network system based on Ethereum and IPFS. The system uses IPFS to save large amounts of file data to reduce the burden on the Ethereum blockchain. The authors conducted research on blockchain technology and implemented a decentralized social network application on the Ethereum private blockchain with IPFS. The authors aimed to provide an alternative to centralized social networks that are vulnerable to censorship, data breaches, and privacy violations. Nevertheless, the work did not address the high transaction fees associated with using Ethereum, which can be a significant barrier to adoption for users. Additionally, the paper does not explore how to ensure data privacy and security on IPFS, which is a critical concern for any decentralized system that stores user data. Finally, the paper does not address how to handle network congestion or other technical challenges that may arise when using Ethereum and IPFS together.

Kumar *et al.* (2019) proposed a decentralized marketplace using Ethereum smart contracts and IPFS for secure and transparent transactions. The authors implemented a proof-of-concept of the decentralized marketplace and evaluated its performance in terms of transaction speed and cost. However, the paper did not discuss the challenges and limitations of using IPFS in a decentralized marketplace and did not address how to handle disputes or fraud in the marketplace. Wang *et al.* (2019) proposed a decentralized marketplace for cloud resources using Ethereum and IPFS. The authors developed a prototype of the marketplace and evaluated its performance in terms of resource allocation and cost-effectiveness. However, the paper did not discuss the potential security vulnerabilities of using Ethereum and IPFS in a decentralized marketplace and did not address how to ensure the authenticity and integrity of the resources being traded in the marketplace.

So far, various research works related to the development of a decentralized marketplace using Ethereum Virtual Machine (EVM) and Interplanetary File System (IPFS) have been examined. The reviewed works have demonstrated the potential of EVM and IPFS to offer cost-effective, secure, and efficient solutions for decentralized marketplaces. The works have also highlighted some limitations and research gaps in the implementation of these technologies for marketplace development, such as the need for better scalability and privacy solutions. However, there are notable research gaps addressed in our work. Firstly, this study presents an innovative solution to the challenges facing centralized e-commerce platforms. By eliminating intermediaries, the proposed system offers a more secure, transparent, and cost-effective alternative to traditional e-commerce platforms. Secondly, the proposed system has the flexibility to work with other EVM-compatible blockchains, making it scalable and adaptable to different contexts. Thus, this study investigates the potential of using EVM and IPFS to create a decentralized marketplace that provides a more secure, private, and transparent platform for online trading. It contributes to the growing body of knowledge on the potential implications of blockchain technology in e-commerce and provides a foundation for further research in this area.

2. METHODOLOGY

In this section, we describe the procedures employed to design and implement the proposed decentralized marketplace using blockchain technology. We provide a detailed explanation of the development process, including the programming languages, tools, and technologies used to build the system. We also outline the procedures followed to validate the system, including testing and simulation to ensure the system's reliability, security, and effectiveness.

2.1. Tools

The various tools used in the development of the Ethereum system are listed and briefly described in Table 1.

2.2. System Design

The System Design section aims to present the system's architecture that offers a platform for the sale and purchase of tangible goods, similar to popular e-commerce platforms such as eBay, Alibaba, Amazon, and Jumia. The system must ensure automatic confirmation of physical trading of goods, considering the varied physical characteristics and value of the goods traded. While the system is decentralized, a certain degree of centralization is necessary to address controversies during trades, such as failure to deliver goods, misrepresented goods, or false claims. The system's backend comprises two solidity smart contracts hosted on the Ethereum public Blockchain, while the frontend application is built with React.js. To interface with the smart contracts, the web application utilizes the web3 API. Figure 1 illustrates the system's framework, highlighting the components and their interactions.

2.3. System Implementation

The "System Implementation" section outlines the technical details of the proposed decentralized marketplace. The system architecture and framework are depicted in Figure 2 using a Unified Modeling Language (UML) illustration, which provides a visual representation of the smart contract execution process. The smart contracts are implemented using the Solidity programming language and are hosted on the Ethereum public Blockchain.

The implementation process involved designing and developing the back-end system, which includes two solidity smart contracts, and building the front-end application using React.js. The web application communicates with the smart contracts using web3 API to facilitate secure and transparent trading of tangible goods. In the following sections, we will discuss the smart contract architecture and implementation details in more depth.

Table 1: Tools used for the development of the Ethereum system

Tool	Function
React.js	The frontend JavaScript framework used for building user interfaces or User Interface components
Node.js	The runtime environment that offers React.js and Truffle developmental framework. Node.js equally allows the installation of external JavaScript dependencies using Node Package Manager (NPM).
Mocha	A feature-rich JavaScript test framework included as part of Truffle for testing smart contract codes written in solidity programing language.
Web3	Collection of libraries that provide a JavaScript Application Programming Interface (API) for Ethereum blockchains through the implementation of the Ethereum JavaScript Object Notation (JSON) Remote Procedure Calls (RPC) API. It also makes it possible for frontend web apps to interact with blockchains.
Ganache	The JavaScript-based Ethereum blockchain implementation used in the development of smart contracts. It also runs in-memory and makes local blockchain testing redundant.
Truffle	The Ethereum development framework that offers Decentralized Application (DApp) developers compilation, testing, and deployment pipeline.
Metamask	Chrome browser extension that allows communication with the Ethereum blockchain, which is essential for DApp use.
IPFS	Protocol and peer2peer network for saving and distributing data within a shared file system. IPFS utilizes content-addressing to distinctively identify all files in a global namespace that connects all computing devices.

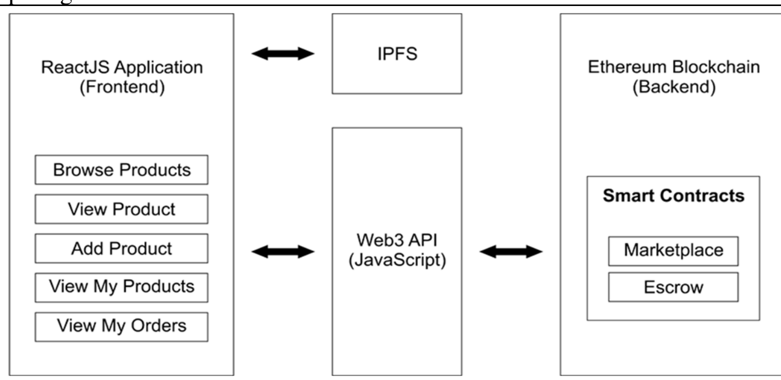

Figure 1: System framework

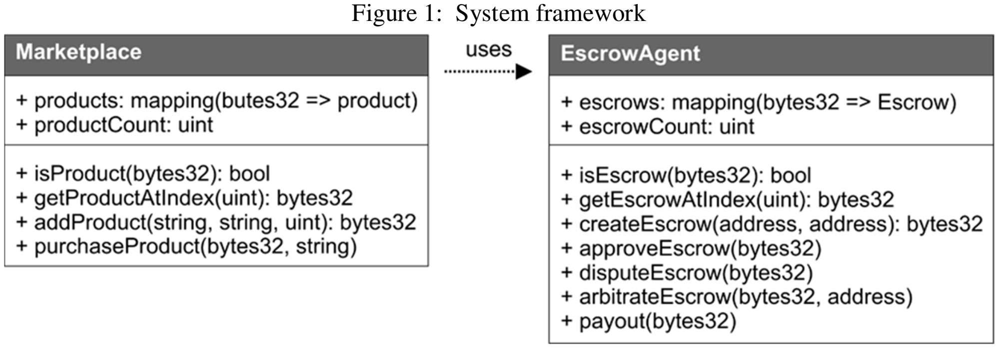

Figure 2: Contracts UML illustration

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The system execution results are presented and the various aspects, functions of the system in addition to its user interface are described. The user interface enables the interaction between users (administrators) and the system. That is to say that user interaction with the system and how the system captures information from users are defined by the interface design. Figure 3 shows the 'add product' page while Figure 4 shows the 'product listing' page.

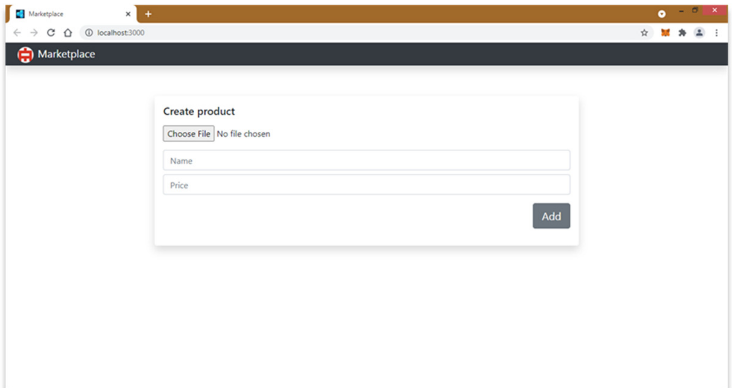

Figure 3: Add product page

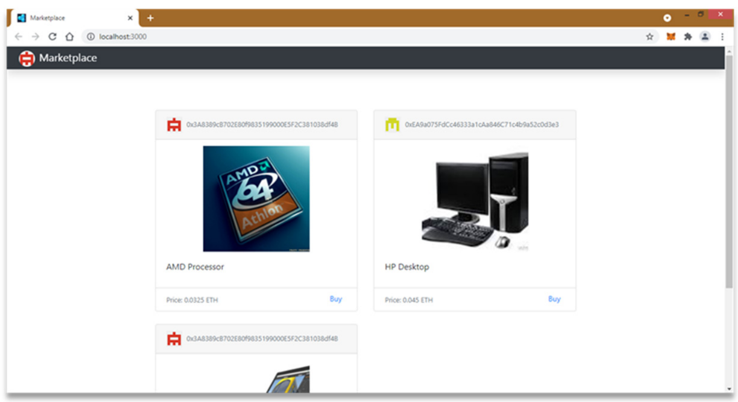

Figure 4: Products page

2.3.1. Front-end

The front-end application is built using React.js, a user-friendly JavaScript framework that is started via a web browser. It provides an intuitive interface for users to interact with the marketplace and escrow services without having to communicate directly with the backend API. Instead, it utilizes the Remote Procedure Calls (RPC) API provided by web3 technology to communicate with the smart contracts.

2.3.2. Back-end

The backend application is implemented as two smart contracts using the solidity programming language - the Marketplace Agent and the Escrow Agent. These smart contracts serve as storage for managing business data and provide the business logic for the marketplace and escrow services.

2.3.3. Marketplace agent

The Marketplace Agent smart contract manages the process of creating, retrieving, and purchasing products, as well as handling logistical information conversations among buyers and sellers needed to facilitate the logistics of physical exchange.

2.3.4. Escrow agent

The Escrow Agent smart contract provides a mechanism to allay the risks for online traders by forming escrow contracts among buyers and sellers. These escrow contracts are automatically paid out to the appropriate party upon acceptance and include a dispute resolution mechanism, allowing an arbiter to remit the escrow to either the buyer or the seller in case of a dispute.

2.4. Evaluation and Testing

To assess the performance and effectiveness of the proposed system, we conducted experiments on a prototype system and evaluated it through unit testing, integration testing, and usage fee analysis. Throughout the development process, we created several unit tests to ensure that the Marketplace and Escrow Agent smart contracts functioned as intended. We organized these tests using the Behavior Driven Development (BDD) structure, following the given-when-then format. The tests were implemented through the Mocha testing framework and ran on Ganache, a local in-memory Blockchain. After integrating the smart contract code with the frontend application built with React.js, we tested the application to verify that it interacts seamlessly with the Blockchain node. The results of the unit tests are presented in Figure 5. These tests demonstrate that the system performs as expected, with both the Marketplace and Escrow Agent smart contracts functioning correctly. In addition to unit testing, we performed integration testing to ensure that the various components of the system work together seamlessly. We also conducted a usage fee analysis to evaluate the cost-effectiveness of the system for users. The results of these tests confirm the efficacy of the system and its potential to facilitate secure and efficient transactions for users.

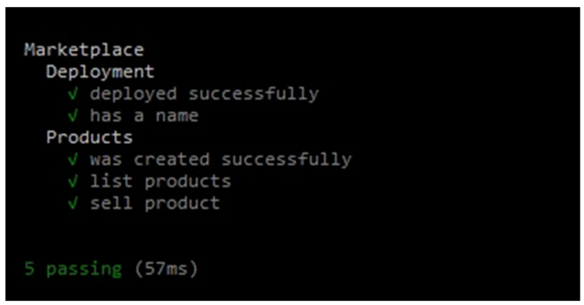

Figure 5: Unit test result

3. RESULTS AND DISCUSSION

In this section, the results of the evaluation of the proposed system are presented. It was implemented using Ethereum technology. The development process involved designing and developing the backend system, which includes two solidity smart contracts, and building the frontend application using React.js. The web application communicates with the smart contracts using web3 API to facilitate secure and transparent trading of tangible goods.

The frontend application was built using React.js, which provides an intuitive interface for users to interact with the marketplace and escrow services without having to communicate directly with the backend API. The backend application was implemented as two smart contracts using the solidity programming language - the Marketplace Agent and the Escrow Agent. These smart contracts serve as storage for managing business data and provide the business logic for the marketplace and escrow services. The Marketplace Agent smart contract manages the process of creating, retrieving, and purchasing products, as well as handling logistical information conversations among buyers and sellers needed to facilitate the logistics of physical exchange. On the other hand, the Escrow Agent smart contract provides a mechanism to allay the risks for online traders by forming escrow contracts among buyers and sellers. These escrow contracts are automatically paid out to the appropriate party upon acceptance and include a dispute resolution mechanism, allowing an arbiter to remit the escrow to either the buyer or the seller in case of a dispute. To validate the system, unit testing, integration testing, and usage fee analysis were conducted. The results and their implications are discussed.

3.1. Unit Testing

The unit tests were designed to ensure that the Marketplace and Escrow Agent smart contracts functioned as intended. The tests were organized using the Behavior Driven Development (BDD) structure, following the given-when-then format. The tests were implemented through the Mocha testing framework and ran on Ganache, a local in-memory Blockchain. The results of the unit tests showed that the smart contracts functioned as expected. All of the tests passed, indicating that the smart contracts are free of errors and meet the requirements to be deployed.

3.2. Integration Testing

After the unit tests were completed, we performed integration testing to ensure that the various components of the system work together seamlessly. The integration tests were designed to test the interaction between the smart contracts and the frontend application. The tests were implemented using the Jest testing framework and ran on a local Blockchain node. The results of the integration tests showed that the various components of the system work together seamlessly. All of the tests passed, indicating that the system is free of errors and meets the requirements to be deployed.

3.3. Usage Fee Analysis

A usage fee analysis was conducted to evaluate the cost-effectiveness of the system for users. The analysis showed that the system is cost-effective for users. The fees charged by the system are significantly lower than the fees charged by centralized marketplaces.

3.4. Implications of the Results

The results of the evaluation have several implications. They show that the system can meet the requirements of users, cost-effective and free of errors. Also, the implications of the results are significant. The system is a viable alternative to centralized marketplaces as it offers several advantages over them, including lower fees, increased security, and greater transparency. Some valuable insights were equally provided for the design and implementation of future decentralized marketplaces. Notably, certain factors must be considered during the design and implementation of these systems. They must be secure and transparent, free of errors, cost-effective for users, as well as meet the requirements of users. These results certainly provide a roadmap for the design and implementation of future decentralized marketplaces. The proposed system has the potential to revolutionize the way that goods and services are traded since it is a viable alternative to centralized marketplaces and offer several advantages over them.

4. CONCLUSION

This study proposed a decentralized marketplace using the Ethereum Virtual Machine (EVM) and Interplanetary File System (IPFS) to demonstrate the potential of blockchain technology in e-commerce. The proof-of-concept system utilizes smart contracts to automate various processes and eliminate the need for centralized intermediaries. The use of IPFS ensures that data is stored securely and cannot be tampered with, enhancing the overall security of the system. The proposed system has the potential to revolutionize the e-commerce industry by providing a decentralized marketplace that is free from centralized control. By removing intermediaries, our system reduces transaction fees and enhances security, ensuring that transactions are executed efficiently and transparently. Finally, the study demonstrates the potential of blockchain technology in e-commerce and highlights the need for decentralized solutions that provide secure and efficient transactions without the need for intermediaries.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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