Securing Crowdfunding Platforms using Polygon Blockchain Technology

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***Abstract*—This study aims to enhance the security and transparency of crowdfunding platforms by implementing Polygon blockchain technology. Traditional crowdfunding systems are often vulnerable to mismanagement and lack of accountability. To address these issues, a blockchain-based crowdfunding website was developed using smart contracts deployed on the Polygon network. This project follows a software engineering approach using a prototyping development model. The system is built using Solidity for smart contracts and React.js for the front end, and it is integrated with the MetaMask cryptowallet to realize authentication and transaction execution. The implementation results demonstrate that the system successfully facilitates secure, transparent, and decentralized donation processes. All transactions and fund flows are permanently recorded and verifiable through PolygonScan. User validation is conducted without conventional login systems, relying instead on wallet-based authentication, which reduces the risk of credential theft. Functional testing confirmed that all core features, including donation program selection, transaction history recording, and MetaMask integration, performed as expected. In conclusion, the developed system successfully achieves the research objective of providing a more secure and trustworthy crowdfunding platform through the application of Polygon blockchain technology**

Keywords— Blockchain, Crowdfunding, Polygon, Smart Contracts, MetaMask, Data Security

I. INTRODUCTION

Blockchain, introduced by Satoshi as the backbone of Bitcoin in 2008 [1], has transformed the way we conduct digital transactions by providing a secure and transparent method that eliminates the need for third-party involvement. This innovative technology uses a distributed ledger to create an immutable chain of interconnected transaction blocks. Blockchain has captured the interest of various sectors, including healthcare [2-5], transportation [6, 7], simulator applications [8-13], and blockchain development itself [14-17].

Through the Polygon network, blockchain is reshaping crowdfunding by enhancing security, transparency, and efficiency. It allows for fundraising from small contributions without relying on traditional sources [18, 19]. By leveraging its decentralized and immutable nature, this technology addresses challenges such as high transaction costs and cyber vulnerabilities.

Polygon, a Layer 2 scaling solution for Ethereum launched in 2017, significantly improves transaction scalability and efficiency. It provides a modular framework for developers to create decentralized applications (dApps) [20]. Additionally, it enables interoperability between different blockchain networks, acting as an "Internet of Blockchains" while using Ethereum's robust security.

The decision to implement Polygon for crowdfunding is driven by its scalability, cost-effectiveness, and security, making it an ideal choice for high-volume micro-transactions [21, 22]. Polygon mitigates weak points with decentralization and utilizes smart contracts, ensuring data integrity and transparency [23, 24]. Besides helping to prevent cyber-attacks, Polygon's cryptography based security features are less energy intensive than Ethereum [25].

Blockchain technology enhances crowdfunding systems by incorporating an immutable ledger, thereby increasing transparency and accountability [26]. Blockchain technology also has the additional benefit of being less expensive and more efficient because it eliminates the need for a third party. Smart contracts automate and eliminate intermediaries to simplify and reduce the burden of AML and KYC compliance [27]. Stablecoins such as USDC and USDT contribute to monetary stability and facilitate these transactions [28].

Frameworks like DAOs, promotes active participation by enabling token holders to vote. The system increased user trust by eliminating reliance on a centralized systems [29]. Nonetheless, advanced knowledge requirements, regulatory intricacies, technical proficiencies, and concerns regarding data privacy remain problematic [30]. Other highlighted barriers to widespread implementation include accessibility and user scalability, as well as complicated financial systems across various jurisdictions [31].

With growing concerns, the potential of blockchain technology to transform crowdfunding remains unparalleled, owing to its decentralized structure, transparent nature, and robust security. This research focused specifically on the Polygon network and smart contracts to understand how blockchain technology can increase trust and efficiency, particularly in crowdfunding activities and to develop more secure and sustainable networks for crowdfunding platforms by optimally utilizing blockchain technology [32]. The next sections will present the literature review, outline the methodology, discuss the findings, and provide concluding remarks alongside prospects for future research.

II. STUDY LITERATURE

This research examines the implementation of blockchain technology on crowdfunding platforms. Several comparative studies have been conducted previously, focusing on how smart contracts, digital wallets, and web frameworks can improve transparency, efficiency, and security in online fundraising. This section reviews research related to blockchain-based crowdfunding platforms and other potentially interconnected components.

A. Blockchain Technology and Smart Contracts

Blockchain is a distributed ledger technology that allows for permanent data recording without the need for a central authority. Smart contracts enhance public trust by automatically executing agreements without intermediaries when applied to crowdfunding [33]. The system ensures transparency and accountability, as every transaction is permanently recorded. Blockchain networks, using Polygon, are considered more efficient than Ethereum due to lower transaction fees and faster processing speeds [34]. These two system efficiencies are crucial for crowdfunding systems involving a large number of micro-transactions, allowing developers to allocate more funds to charitable projects, for example, and facilitating fundraising activities more quickly and accurately..

B. Crowdfunding System

Crowdfunding systems that discuss here is involving raising funds from the general public using online platforms. This crowdfunding is following four main models: donation-based, reward-based, loan-based, and equity-based [35]. Two important things, which is, transparency and accountability are crucial for a successful fundraising campaign. Without them, public trust can quickly erode [36].

Traditional crowdfunding systems generally struggle with transparency. This can lead to the potential for misuse of funds. Blockchain can serve as a strategic solution, ensuring transaction integrity [37]. By permanently recording every transaction, blockchain minimizes the risk of fraud, while smart contracts ensure that funds are only disbursed when predetermined requirements are met, thereby increasing trust and encouraging participation from a wide range of stakeholders.

C. Digital Wallet and Web Integration

Metamask is a crypto wallet that serves as a medium for authenticating dApps and validating transactions, supported by a user-friendly interface. With its user-friendly interface, Metamask makes it easy for users to manage their crypto assets and conduct direct transactions without relying on third parties. Metamask's integration with crowdfunding platforms not only reduces transaction fees but also accelerates fundraising, allowing users to contribute directly without lengthy verification processes. Furthermore, Metamask supports smart contract interactions, which can improve efficiency and security [38].

D. Ether.js for Frontend-Blockchain Interaction

Ether.js is a user-friendly JavaScript library that enables developers to effortlessly interact with Ethereum-compatible blockchains, such as Polygon, directly from the decentralized application (dApp) frontend [39]. This library simplifies blockchain engagement for developers by providing a straightforward application programming interface (API) for tasks such as sending transactions, querying smart contract data, and securely managing wallets. Ether.js serves as a crucial link between the user interface and the blockchain network in the context of blockchain-based crowdfunding platforms. This system allows all participant to contribute during fundraising through smart contracts. The system can track their contributions, and access various features provided within the platform. These system will eliminates the need for users to install third-party applications or extensions. This feature is particularly beneficial for platforms operating on the Polygon network, whose transaction fees are claimed to be significantly lower than those of the Ethereum network, thus improving the overall user experience [40].

E. System Integration

Developing a blockchain-based crowdfunding platform involves many various technologies in the process. The system adopts a decentralized approach with a multilayer architecture, using React.js for the user interface, Solidity for smart contracts, Ether.js for frontend-blockchain interaction, and Metamask for transactions. These combination mention above is ensure optimal functionality and smooth user experience. Developing the Polygon network for its efficiency, the platform supports large-scale crowdfunding with micro-transactions [41]. The React.js creates a dynamic interface and user friendly, whereas Ether.js facilitates smart contract interactions [42]. Metamask provides facilities for all users to be able to secure, manage accounts and transactions made.

F. PolygonScan

PolygonScan is a block explorer that allows users to constantly monitor transaction activity on the Polygon network. Transaction verification is possible, ensuring transparency of fund flows and transaction status. This tool is necessary to maintain security and transparency in blockchain systems, especially for smart contracts in crowdfunding [43].

G. Polygon (Amoy Testnet)

The Polygon Labs proposed a new testnet named Amoy Testnet. This testnet hope that can replace the Mumbai Testnet with a more stable environment for testing dApps [44]. Amoy Testnet uses improved infrastructure and integrates services, such as Chainlink, for efficient token distribution [45, 46], supports RPC endpoints that compatible with the mainnet, making the developers can test their development application before deployed on the mainnet [45].

H. Smart Contract Security in Crowdfunding Systems

The use of smart contracts offers both significant benefits and challenges for developers, particularly when building crowdfunding systems. The advantage of smart contracts lies in their automation, which means, after the systems is deployed, smart contracts will execute predefined rules without any human interaction, thereby will gain user accountability and trust [46].

The immutable nature of smart contracts is one of the weaknesses of smart contracts. This means that any coding errors or vulnerabilities, such as those seen in The DAO hack, cannot be fixed after deployment, leaving them vulnerable to exploitation. Common issues include re-registration, integer overflows, and access control misconfigurations [47]. While there are several mitigation strategies that have been discovered by previous researchers, only a small percentage can effectively address these vulnerability issues [48].

III. Research Methodology

This chapter outlines the research methodology, detailing the approach and specific methods used to achieve the study's objectives. It describes the research type, data collection methods, and system development stages, providing a framework for implementing Polygon-based blockchain technology to enhance crowdfunding platform security.

A. Type of Research

This study employs a design and development research approach aimed at designing and implementing Polygon-based blockchain technology to improve crowdfunding website security. The focus is on technology application and system evaluation rather than measuring respondents' perceptions, as seen in pure quantitative research.

B. Data Collection Methods

Data collection methods are carried out using two main approaches:

- Literature Study, a literature review of scientific journals, articles, and other documentation related to blockchain technology, smart contracts, and crowdfunding systems was conducted. This study aimed to understand security, blockchain architecture, and smart contract implementation on the Polygon network [49, 50].
- System Requirements Analysis, this stage identifies security gaps in conventional crowdfunding platforms and determines features for integration into blockchain-based systems. It involves analyzing decentralized system architecture and implementing smart contracts to mitigate fund misuse and transaction data manipulation.

C. System Development Stages

The system development methodology follows a prototype approach, illustrated in Fig. 1.

- System design employs a multilayer architecture, with React.js for the interactive user interface. Smart contracts are written in Solidity and implemented on the Polygon network, chosen for its scalability and low transaction costs. Metamask is used for authentication and digital asset management.
- System implementation involves deploying the smart contract on the Polygon test network (Amoy Testnet) before moving to the main network. Ether.js facilitates interaction between the frontend and blockchain, allowing users to call smart contract functions directly from web applications.
- System testing is conducted using the black-box method, focusing on system outputs without considering internal implementation. This ensures the system functions as intended, particularly regarding fund flow security, user validation, and transaction recording transparency. All transactions are automatically recorded on the blockchain and can be verified using block explorers like PolygonScan or Etherscan.

IV. Result and Discussion

This chapter presents and analyzes the research findings related to the objectives outlined earlier. It discusses the implementation of Polygon-based blockchain technology to enhance crowdfunding platform security, highlighting key outcomes, challenges faced during development, and implications for future crowdfunding security.

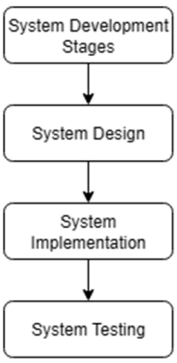


Fig. 1. System Development Stages

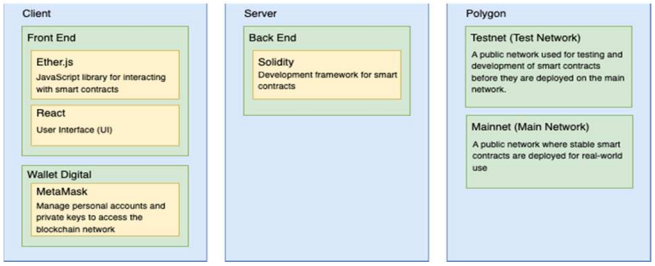


Fig. 2. System Architecture

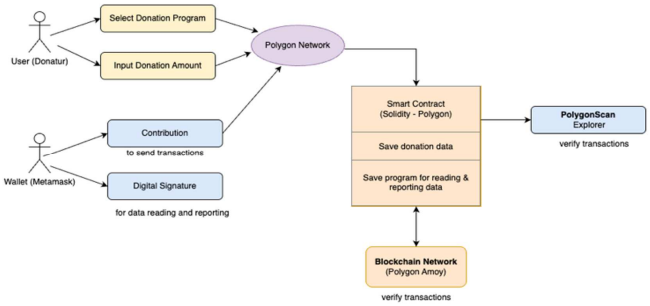


Fig. 3. Application Structure and Function

This study introduces a new approach to blockchain-based crowdfunding by using a broader campaign classification system, moving away from detailed project listings typical of previous Ethereum-based platforms. Donation campaigns are grouped into categories like Mandiri (for MSMEs) and Harmoni (for Islamic peace-building), simplifying navigation for first-time donors.

Unlike earlier studies that faced high transaction fees and slow processing on Ethereum, this research utilizes Polygon, a Layer-2 solution that significantly lowers gas fees and increases transaction speed. This makes the system more effective for micro-transactions, which are crucial for frequent donations [51]. Table 1, shows the gas price and gas used in this experiments.

A. System Architecture

The proposed system architecture integrates a web-based crowdfunding platform with Polygon blockchain technology, enabling decentralized, transparent, and secure communication between users and service providers, thus reducing reliance on third parties. This architecture is illustrated in Fig. 2.

Table 1. Gas Price and Gas Used

No	Tx Hash2	Gas Price	Gas Limit	Gas Used	Gas Fee (Gwei)	Burnt Fee
1	0x038……48df0	29.100000015 Gwei (0.000000029100000015 POL)	384996	189824	0.000000015	0.00000000000284736 POL (< $0.000001)
2	0x0d3……bd934	97.000000006 Gwei (0.000000097000000006 POL)	384996	189824	0.000000015	0.00000000000284736 POL (< $0.000001)
3	0xdb0……3ae52	72.75 Gwei (0.00000007275 POL)	384996	189824	0.000000015	0.00000000000284736 POL (< $0.000001)
4	0x0d3……bd934	97.000000006 Gwei (0.000000097000000006 POL)	384996	189824	0.000000015	0.00000000000284736 POL (< $0.000001)
5	0x86f……30ed8	97.000000002 Gwei (0.000000097000000002 POL)	384996	189824	0.000000015	0.00000000000284736 POL (< $0.000001)
6	0x990……52c50	1.500000015 Gwei (0.000000001500000015 POL)	229985	229985	0.000000015	0.00000000003449775 POL (< $0.000001)
7	0x458……44274	1.940970015 Gwei (0.000000001940970015 POL)	212885	212885	0.000000015	0.00000000003193275 POL (< $0.000001)
8	0x30d……0ee4d	1.500000015 Gwei (0.000000001500000015 POL)	212885	212885	0.000000015	0.00000000003193275 POL (< $0.000001)
9	0x65b……05eaa	33.434687507 Gwei (0.000000033434687507 POL)	192498	189824	0.000000015	0.00000000000284736 POL (< $0.000001)
10	0x5bb……6def3	26.675000015 Gwei (0.000000026675000015 POL)	169254	166763	0.000000015	0.00000000002501445 POL (< $0.000001

B. *Security Process*

Polygon blockchain enhances crowdfunding security through several approaches:

- Immutability: Once recorded, transaction data cannot be modified, preventing fund manipulation by project owners [52].
- Smart Contract Logic: Funds are disbursed only when specific conditions are met, such as reaching a target or receiving contributor approval [53].
- Decentralization: Data is recorded across a distributed network, making it resistant to central server attacks [54].

Polygon offers high efficiency with low gas fees (~$0.001 per transaction) compared to Ethereum, while maintaining comparable security levels [29].

C. *Structure and Function of Polygon Blockchain Technology in Crowdfunding Case Study*

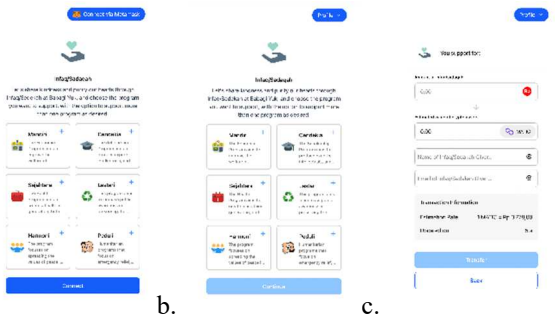
This crowdfunding application addresses traditional platform drawbacks, such as lack of transparency, high fees, and fraud risk. Built on the Polygon blockchain, it utilizes smart contracts and digital wallets like MetaMask. The application consists of modular components facilitating the blockchain-based donation process, as shown in Fig. 3.

Implemented security features include complete decentralization, ensuring no single entity controls the funds, with all operations managed by smart contracts [23]. This enhances transparency, allowing real-time verification of transactions, voting, and fund flows via PolygonScan [43].

D. *User Interface of Polygon Blockchain Technology in Crowdfunding Case Study*

Screenshots of the user interface for the blockchain-based crowdfunding application highlight key features, including program selection for donations and MetaMask wallet connection. The intuitive design ensures donor information transparency. Users can view donation programs, and upon connecting their MetaMask wallet, the interface updates to show wallet details. The donation form allows users to enter amounts and view exchange rates, as shown in Fig. 4. A summary of transaction data detailing user donations on the Polygon network is also available, as illustrated in Fig. 5.

Our approach differs significantly from RESTI's Ethereum-based crowdfunding solution. While their platform struggles with Ethereum's high and unpredictable transaction fees (sometimes costing several dollars for small donations), our Polygon Layer-2 solution brings costs down to about $0.001 per transaction. This makes micro-donations practical and creates a more inclusive environment for crowdfunding campaigns with many small contributors [55].



a. b. c.

Fig. 4. (a) Donation Program Selection Before Wallet Connection; (b) Donation program selection interface after MetaMask wallet is connected; (c) Donation form view after selecting a program and connecting to MetaMask

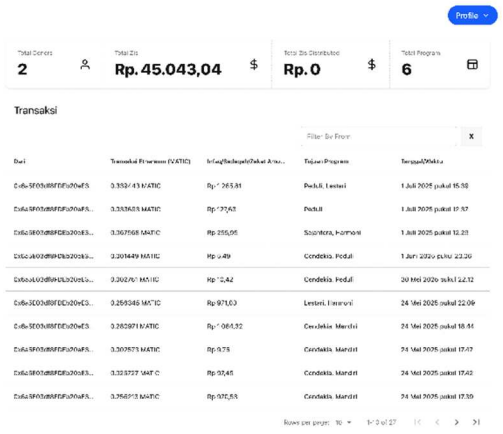


Fig. 5. History of fund transactions recorded on the Polygon network

Our platform offers both affordability and superior performance, processing thousands of transactions per second compared to Ethereum's 15, ensuring instant confirmations even during peak traffic. Utilizing the Amoy Testnet provides better stability than standard Ethereum testnets, along with Chainlink integration and transparent monitoring via PolygonScan. The result is a platform that maintains blockchain's security and decentralization while delivering a smooth, frustration-free experience for donors and developers.

V. CONCLUSION

The findings of this research demonstrate that implementing Polygon blockchain technology on crowdfunding websites can enhance the security, transparency, and efficiency of fund management and project validation. The findings of the implementation system built

using smart contracts and integration with the Polygon network demonstrate the capacity for automated, permanent transaction recording, and immutability. The system testing showed that the primary functions operate effectively and align with the initial research objectives, specifically the development of a more secure and reliable crowdfunding platform. Consequently, the research objective of developing a crowdfunding website that uses Polygon blockchain technology to enhance system security was achieved. The integration of this proposed system will encourage further research especially when using blockchain technology, such as refinements and feature additions to meet the needs of future users who require more security and complex systems.

VI. Future Works

Given the very promising results of this study, further investigation into the potential uses of blockchain technology, particularly in the crowdfunding realm, may be warranted. For subsequent analyses, it is recommended that system development not only focus on technical aspects, but also consider regulations and user literacy regarding crypto technology in Indonesia. Subsequent research endeavors may encompass exploring more sophisticated smart contracts, such as an escrow system predicated on donor voting or the automation of project-milestone-based fund reporting. Furthermore, adopting a user-centered design approach is imperative to enhance the system interface's user-friendliness. Integration with a verified digital identity system can also improve the security and accountability aspects of the donation process.

AUTHOR CONTRIBUTION STATEMENT

Viddi Mardiansyah did the writing, investigation, methodology, and editing. Rafi Johari Wilistianto assisted the writing and editing. Luhur Bayuaji assisted the investigation and editing. Mochammad Haldi Widianto completed the scientific paper by considering revisions from reviewers until completion. Therefore, all authors contributed to this scientific article.

AI Usage Declaration

During preparation for this work, the author utilized the use of Artificial Intelligence (AI and) to explore for pertinent materials. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Data Availability

The data used for this study are openly available at: https://github.com/Rafijohari18/crowdfunding-blockchain

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