CHAPTER I
INTRODUCTION

1.1 Background

The rapid evolution of digital technology over the past two decades has significantly transformed the ways in which individuals interact, transact, and finance diverse economic activities. Prominent among the innovations within the digital economy paradigm is crowdfunding, a mechanism designed to mobilize capital from the public via online platforms to support specific projects, commercial ventures, or social initiatives. In Indonesia, the adoption of this model is exemplified by platforms such as Kitabisa and GandengTangan. Fundamentally, these systems bridge individuals or groups requiring capital with a broader public willing to extend direct financial support, thereby bypassing traditional financial intermediaries. However, conventional crowdfunding frameworks remain inherently centralized, wherein the entirety of fund management and transaction verification relies upon a singular platform provider. This centralized dependency engenders several critical vulnerabilities, including the potential misappropriation of funds, elevated operational overheads, and a deficiency in transparency that collectively diminish public trust [1].

To mitigate these critical vulnerabilities, blockchain technology has emerged as a pivotal innovation capable of revolutionizing digital transaction frameworks. Fundamentally, blockchain is a distributed ledger technology (DLT) that enables transactions to be recorded in a transparent, secure, and immutable manner [2]. Within this architecture, transaction data is replicated across numerous nodes in a peer-to-peer (P2P) network without the oversight of a centralized authority, thereby mitigating the risk of malicious manipulation and eliminating single points of failure. The hallmark advantage of blockchain lies in its capacity to preserve data integrity through robust consensus mechanisms, such as Proof of Work (PoW) and Proof of Stake (PoS), which guarantee that every transaction appended to a block has been comprehensively validated by the entire network [3]. Consequently, these intrinsic characteristics position blockchain as a highly viable solution for public funding frameworks that demand elevated levels of transparency and systemic trust.

Furthermore, the advent of the smart contract concept within the blockchain ecosystem signifies a new paradigm in the automation of digital processes. Smart contracts are self-executing programs deployed on a blockchain that autonomously run predefined logical commands without requiring human intervention [4]. By leveraging smart contracts, transactional activities can be executed seamlessly without third-party intermediaries, thereby minimizing the propensity for human error and optimizing both operational time and costs. In the context of crowdfunding, smart contracts facilitate the automated governance of fund distribution, the validation of contributions, and the enforcement of project stipulations. For instance, capital is disbursed to project developers exclusively upon reaching the predefined funding threshold; conversely, if the target remains unmet, funds are systematically refunded to the contributors [5]. Consequently, the deployment of smart contracts fosters participant trust, as all foundational rules are transparently embedded within the source code, which remains openly auditable by any party.

Although blockchain technology and smart contracts address the challenges of centralization, transparency, and accountability inherent in conventional crowdfunding frameworks, their direct deployment on the Ethereum network as a Layer 1 solution introduces a new set of challenges. Specifically, Ethereum is constrained by critical limitations regarding scalability and operational efficiency. As transaction volumes surge, the Ethereum network frequently suffers from network congestion, which precipitates a substantial escalation in transaction costs, commonly referred to as gas fees [7]. This economic and technical bottleneck constitutes a primary barrier to the widespread adoption of decentralized applications, particularly within crowdfunding ecosystems that inherently rely on a high volume of microtransactions. To address these architectural constraints, Layer 2 scaling technologies have been developed to serve as secondary frameworks that process transactions off-chain, subsequently committing the final states to Layer 1 to preserve systemic security and data validity [8].

This approach facilitates an expansion of transaction capacity without compromising the network's inherent security guarantees or decentralized architecture. A variety of Layer 2 scaling paradigms have emerged, most notably

Optimistic Rollups (such as Arbitrum, Optimism, and Base) and Zero-Knowledge Rollups, or ZK-Rollups (such as zkSync, Starknet, and Polygon zkEVM). Fundamentally, these technologies mitigate the computational burden on the mainnet by aggregating a substantial volume of discrete transactions into a single batched data package prior to transmitting it back to Layer 1 for validation [9]. Through this batching mechanism, Layer 2 solutions drastically enhance network throughput potentially by orders of magnitude while concurrently minimizing transaction costs. Among the rapidly advancing Layer 2 implementations, Base has emerged as a prominent Optimistic Rollup framework that maintains full Ethereum Virtual Machine (EVM) compatibility, specifically engineered to optimize transactional efficiency at a fraction of the cost [10].

The Layer 2 paradigm fundamentally alters the architecture of the blockchain ecosystem by balancing three core pillars: security, scalability, and decentralization a conceptual trade-off widely formalized as the blockchain trilemma. In this context, Layer 2 solutions extend beyond mere technical patches for network performance enhancement; they serve as the foundational architecture for developing next-generation decentralized applications that prioritize operational efficiency and user accessibility. The deployment of Layer 2 frameworks, particularly Optimistic Rollups, has been shown to reduce transaction overheads by up to 90% compared to native Layer 1 execution [11]. While various prominent Optimistic Rollup networks exist such as Arbitrum and Optimism the Base network was selected for this study due to several distinct architectural and economic advantages. First, Base is architected upon the OP Stack, which exhibits a high degree of EVM equivalence, thereby guaranteeing seamless and stable smart contract code portability. Second, following the implementation of the Dencun upgrade, Base has consistently maintained a more cost-effective transaction fee structure than Arbitrum or alternative Layer 2 networks. This financial optimization is paramount for crowdfunding platforms characterized by a high volume of microtransactions. Third, the extensive integration of Base within a broad wallet ecosystem significantly enhances accessibility for mainstream users. Ultimately, the implementation of this technology within crowdfunding frameworks yields strategic advantages, including heightened operational efficiency, minimized gas fees, and accelerated transaction finality, all achieved without compromising the fundamental tenets of transparency and security [12].

Based on the aforementioned context, the deployment of Ethereum Layer 2 is presented as a technical solution to address high operational overheads, which constitute a primary vulnerability in traditional crowdfunding systems. Consequently, this research focuses on the development and implementation of a blockchain and smart contract-based crowdfunding application that leverages the Base network as its Layer 2 protocol. In its execution, a clear distinction must be established between the main network (mainnet), which possesses real-world economic value, and the test network (testnet), which is designated for development and experimental purposes. Accordingly, this study utilizes the Ethereum Sepolia network to represent the Layer 1 environment and the Base Sepolia network to represent the Layer 2 framework.

While various Layer 2 networks based on the Optimistic Rollup architecture such as Arbitrum and Optimism are widely available, the Base network was selected for this study based on technical considerations and its alignment with the system's operational requirements. Developed upon the OP Stack, Base exhibits a high degree of compatibility with the Ethereum Virtual Machine (EVM), thereby facilitating the seamless deployment of smart contracts without requiring substantial code modifications. Furthermore, preliminary observations conducted via blockchain explorers within the testnet environment indicate that Base demonstrates significantly lower transaction cost characteristics compared to Layer 1 under equivalent execution scenarios. This economic behavior renders Base highly pertinent for analysis regarding cost efficiency within decentralized crowdfunding applications. Critically, the selection of Base in this research is not intended to assert its absolute superiority over alternative Layer 2 protocols; rather, it serves as a representative model of the Optimistic Rollup paradigm to empirically evaluate transaction cost deltas.

1.2 Research Question

Based on the background detailed above, the specific research questions addressed in this study are formulated as follows:

1. How can a decentralized crowdfunding application architecture that integrates smart contracts be designed to operate effectively within a Layer 2 environment?
2. In what manner can smart contract mechanisms autonomously execute and automate core crowdfunding processes in a transparent and decentralized paradigm?
3. What is the empirical variance in transaction costs (gas fees) between the Ethereum Sepolia (Layer 1) and Base Sepolia (Layer 2) networks during the execution of the crowdfunding application?

1.3 Research Objectives

The primary objectives of this study are articulated as follows:

1. To develop and implement a transparent and secure crowdfunding application based on blockchain architecture and smart contracts.
2. To evaluate the functional behavior of the smart contracts within the crowdfunding application utilizing the black-box testing methodology.
3. To analyze and compare transaction costs (gas fees) between the Ethereum Sepolia (Layer 1) and Base Sepolia (Layer 2) networks.

1.4 Research Benefits

This research is anticipated to contribute significantly to both the advancement of scientific knowledge and the practical application of technology within the field of Information Systems. The specific contributions are delineated as follows:

1. Theoretical Significance, this study contributes to the development of academic literature surrounding blockchain technology and decentralized applications (dApps), particularly regarding the empirical implementation of Layer 2 scaling solutions.
2. Practical Significance, this research serves as a reference framework for digital finance developers in designing and constructing more transparent, efficient, and secure crowdfunding platforms. The deployment of smart contracts on the Base Sepolia (Layer 2) network is expected to mitigate transaction overheads, thereby enhancing user experience and catalyzing the broader adoption of blockchain-based financial systems in Indonesia.

3. Socio-Economic Significance, from a social perspective, this study has the potential to strengthen public trust in online fundraising mechanisms by offering a transparent and tamper-proof architecture. From an economic standpoint, the outcomes of this research can empower individuals and organizations to access capital independently, bypassing reliance on conventional financial institutions.

1.5 Scope of the Study

To ensure a precise and rigorous analytical focus, the scope of this research is constrained by the following parameters:

1. The crowdfunding system operates exclusively on the Ethereum Sepolia network (representing the Layer 1 environment) and the Base Sepolia network (representing the Layer 2 framework).
2. The development of the user interface is restricted to simulating user interactions with smart contracts via a Web3 wallet infrastructure (specifically MetaMask).
3. Functional evaluation is confined to the core operations of the smart contract namely campaign creation, cancellation, donation, fund withdrawal, fund claiming, and refund mechanisms executed through black-box testing methodologies.
4. The comparative analysis is limited to evaluating the transaction costs (gas fees) recorded on the respective blockchain explorers of Ethereum Sepolia (Layer 1) and Base Sepolia (Layer 2).
5. System security considerations are bounded by the implementation of a Reentrancy Guard mechanism at the smart contract code level, excluding formal, third-party cryptographic or architectural security audits.
6. This study focuses strictly on the comparative dynamics between Ethereum Sepolia and Base Sepolia, thereby excluding alternative Layer 2 scaling protocols from its analytical scope.