Review of Peer-to-Peer (P2P) Lending Based on Blockchain

Timotius Victory, Setiadi Yazid
The Faculty of Computer Science, Universitas Indonesia, Depok, 16424, Indonesia

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ABSTRACT

Peer-to-Peer (P2P) lending is a financing business model that has gained popularity in recent years due to the ease of loan application, disbursement, and repayment processes. The volume of Peer-to-Peer (P2P) Lending transactions has a significant growth with more than $103 billion in 2020, according to The Cambridge Centre for Alternative Finance (CCAF). A key distinguishing factor from traditional methods is the integration of technology in both application and repayment. One such technology gaining traction in Peer-to-Peer (P2P) lending is blockchain technology. The popularity of blockchain technology lies in its ability to enhance the transparency of the transaction process. This literature study aims to address three main questions: What are the characteristics of blockchain suitable for Peer-to-Peer (P2P) lending, the benefits of implementing blockchain technology in Peer-to-Peer (P2P) lending, and the challenges of Peer-to-Peer (P2P) lending based on blockchain. This paper uses a systematic literature review guided by well-defined inclusion and exclusion criteria to answer those questions. The findings reveal that there are characteristics of blockchain that can be applied to Peer-to-Peer (P2P) lending such as decentralized, transparency. It can bring numerous benefits to the overall Peer-to-Peer (P2P) lending process, such as eliminating intermediaries in the lending process. However, challenges persist in the implementation of blockchain technology in Peer-to-Peer (P2P) lending like implementing cross-platform, alternate collateral, and others. This research contributes by identifying key blockchain characteristics for Peer-to-Peer (P2P) lending integration, evaluating the benefits of blockchain in Peer-to-Peer (P2P) lending, and examining challenges faced comprehensively. These insights enhance the understanding of blockchain's role in Peer-to-Peer (P2P) lending.

Corresponding Author:

Timotius Victory, Universitas Indonesia, Pondok Cina, Beji, Kota Depok, Jawa Barat, 16424, Indonesia
Email: timotius.victory@ui.ac.id

1. INTRODUCTION

Fintech, or financial technology, is an industry that leverages technology to enhance financial activities [1]. With operational efficiency through technology, fintech can reduce costs, improve profitability, enhance credit risk assessment, and increase the ease of delivery and flexibility of traditional financial services [2], [3].

According to Lee and Shin [4], there are six emerging fintech business models today, namely payment, wealth management, crowdfunding, Peer-to-Peer (P2P) lending, capital markets, and insurance services. Peer-to-Peer (P2P) lending allows individuals to provide financing to other individuals or businesses without intermediaries. In general, there are three entities involved in Peer-to-Peer (P2P) lending: borrowers, lenders, and the Peer-to-Peer (P2P) lending platform.

Peer-to-Peer (P2P) Lending, also known as Online Peer-to-Peer (P2P) Lending, refers to lending activities among individuals through online platforms without traditional financial intermediaries such as banks [5], [6]. In 2005, the world's first Online Peer-to-Peer (P2P) Lending platform, Zopa (https://www.zopa.com), was founded in Buckinghamshire, United Kingdom [7]. Subsequently, several platforms were created, such as Prosper (https://www.prosper.com) [8]. Prosper is the first Peer-to-Peer (P2P) Lending Platform in the United

States, founded in 2005, and has facilitated more than US$ 23 billion in funds and over 1.3 million users. Another platform is Kiva (https://www.kiva.org) [9]. Kiva is a non-profit organization founded in 2005 in San Francisco. With a minimum of US$ 25, lenders can provide loans. Kiva, a Peer-to-Peer (P2P) Lending Platform, is a key pioneer in implementing zero interest in its loans [4].To date, Kiva operates in 80 countries with more than 4.6 million borrowers, 2.1 million lenders, and over 3,000 field partners, and has disbursed more than US$ 1.8 billion in loans. Lending Club (https://www.lendingclub.com) is one of the biggest Peer-to-Peer (P2P) lending platforms in the United State. It was founded in 2006 and has more than 4.7 million users until now [11], [12]. However, at the end of January 2022, Zopa ceased all Peer-to-Peer (P2P) Lending operations and shifted its focus to the banking sector. The decision made by Zopa was due to the management not seeing a way of actually commercially viable continuing in the Peer-to-Peer (P2P) lending business [13].

There are several advantages to Peer-to-Peer (P2P) lending compared to traditional funding institutions. Traditional financing institutions, such as banks, have numerous requirements and stages in the loan application process, including feasibility surveys, credit scores, collateral, insurance, and a relatively long application time to obtain a loan [13], [15], [16]. Peer-to-Peer (P2P) lending is an alternative service that can offer quick, easy, and low-interest-rate funding for those who are not reachable by traditional financing institutions [17], [18].

For lenders, Peer-to-Peer (P2P) lending offers the potential for higher returns compared to depositing or investing in traditional financial institutions [19], [20]. For borrowers, Peer-to-Peer (P2P) lending offers convenience in terms of application, disbursement, and repayment, along with competitive interest rates, without necessarily considering low creditworthiness compared to traditional financing institutions in general [21], [22]. Furthermore, Peer-to-Peer (P2P) lending can improve transaction efficiency and optimize resource allocation [23], offering high efficiency and low transaction costs compared to traditional financing institutions such as banks [24]. However, Peer-to-Peer (P2P) lending also has several disadvantages, such as a lack of supervision from regulators over Peer-to-Peer (P2P) lending platforms, asymmetric information, Default Risk of Loans, lack of trust among lenders, borrowers, and Peer-to-Peer (P2P) lending platforms, as well as the potential for bankruptcy of Peer-to-Peer (P2P) lending platforms, resulting in losses for lenders [13], [26], [27], [28].

Several Peer-to-Peer (P2P) lending Platforms have experienced significant growth. The volume of Peer-to-Peer (P2P) Lending transactions, as indicated in the study according to Cambridge Centre for Alternative Finance (CCAF) "The 2nd Global Alternative Finance Market Benchmarking Report" [29], consistently ranks first among all alternative finance models, such as donation-based crowdfunding, revenue or profit sharing, community shares, mini-bonds, and so on.

One reason for the popularity of Peer-to-Peer (P2P) lending is the utilization of technology in the process, whether through online platforms or mobile apps. This technology allows the borrowing process to take place online without the need for face-to-face interactions between lenders and borrowers, and all entities can still obtain sufficient information to make a transaction decision [30]. In recent years, there has been considerable exploration into the use of technology in Peer-to-Peer (P2P) lending, including the leveraging of blockchain technology. Since first introduced by Satoshi Nakamoto [31], the utilization of blockchain in financial transactions has been adopted within the financial industry, especially financial technology or fintech [32], [29]. The utilization of blockchain can be applied to financial transactions, such as enhancing trust evaluation mechanisms, increasing transparency in transactions, and allowing all entities to review transactions and contracts at any time [34], [35], [36]. The use of blockchain in financial technology can also reduce transaction costs, increase security, and facilitate transactions in an efficient way [37], [29], [39]. The benefits of employing blockchain technology can be applied to the Peer-to-Peer (P2P) lending process. For Example, blockchain technology facilitates the elimination of intermediaries in the lending process, thereby reducing costs associated with the process.

There is previous research related to it, such as in the research studies [16], [25], [29], which discuss the challenges and trends of financial technology, including the potential of Online Peer-to-Peer (P2P) lending, cryptocurrency, and blockchain in the financial sector. The potential benefits of utilizing blockchain technology in Peer-to-Peer (P2P) lending are significant, necessitating a profound understanding of its application in the Peer-to-Peer (P2P) lending process. To gain a deeper understanding of the utilization of blockchain technology in Peer-to-Peer (P2P) lending and to present the state-of-the-art in this research area, conducting a systematic literature review is necessary. This study significantly contributes to understanding blockchain technology in Peer-to-Peer (P2P) lending. Firstly, it identifies key blockchain characteristics suitable for Peer-to-Peer (P2P) lending, clarifying how blockchain enhances the Peer-to-Peer (P2P) lending process. Secondly, the paper assesses the benefits of blockchain in Peer-to-Peer (P2P) lending. Valuable insights into the advantages of blockchain for the overall Peer-to-Peer (P2P) lending process are presented. Thirdly, the study delves into challenges comprehensively. It offers nuanced insights into the obstacles hindering the seamless integration of blockchain in Peer-to-Peer (P2P) lending for future work.

2. METHODS

The methodology used in this research is a systematic literature review. The steps taken in the process of conducting the research can be seen in Fig. 1.

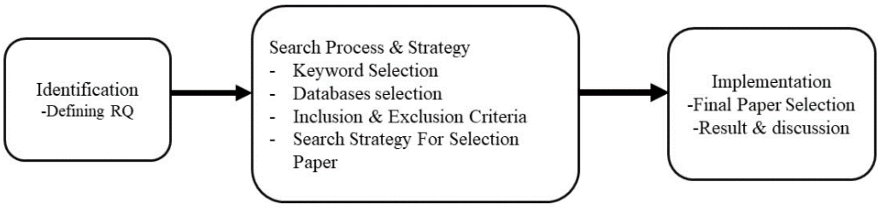

Fig. 1. Research Flowchart

In the initial stage, identification is carried out by determining the research question. Subsequently, a search process strategy is implemented, which includes keyword selection, databases selection, inclusion & exclusion criteria, search strategy for paper selection, and data extraction strategy. Once the search process strategy is established, the implementation involves the final paper selection based on the previously formulated strategies. The results will then be discussed in the results & discussion section.

2.1. Research Questions

The research questions in this article were formulated as follows:

- What are the characteristics of blockchain that are suitable for Peer-to-Peer (P2P) lending?
- What are the benefits of implementing blockchain technology in Peer-to-Peer (P2P) lending?
- What are the challenges of Peer-to-Peer (P2P) lending based on blockchain?

2.2. Search Process

The keywords used for searching literature reviews were as follows, “blockchain and peer-to-peer lending” or “blockchain and p2p lending” or “blockchain and peer to peer lending” to avoid the noise level that can weaken the relevance of the extracted literature due to irrelevant keywords not related to Peer-to-Peer (P2P) lending based on blockchain. This research used IEEE Xplore, Scopus, and ACM databases. The decision to utilize IEEE, Scopus, and ACM databases for the literature review is based on their widely acknowledged reputation and extensive coverage in technology-related domains. This approach ensures a systematic exploration of reputable sources. In this study, data extraction is carried out through a full text review to identify the blockchain platforms used, solved problems, unresolved problems, results, conclusions, and future research.

2.3. Implementation

The selection of articles is based on predefined keywords. Inclusion and exclusion criteria were established, including the choice of articles in English and the exclusion of articles in other languages, limiting the period from 2018 to 2023, and removing duplicate articles. The selection of articles from 2018 to 2023 was intentional to prioritize recent literature in order to capture the most up-to-date trends and advancements in blockchain technology within the context of Peer-to-Peer (P2P) lending based on blockchain. Fig. 2 illustrates the document selection process, beginning with potentially relevant papers and concluding with the final paper based on a full text review.

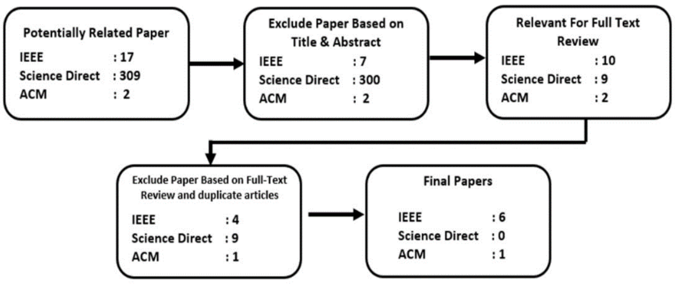

Fig. 2. Selection Process for Final Papers

First, we selected potentially related papers by categorizing them based on IEEE Xplore, Scopus, and ACM databases. Second, after grouping them, we conducted the selection of articles by reading relevant titles and abstracts regarding Peer-to-Peer Lending based on blockchain. Titles and abstracts that did not discuss Peer-to-Peer (P2P) lending based on blockchain were removed. In the third step, we obtained articles with titles and abstracts relevant for a Full Text Review. In the fourth step, we removed duplicate articles by eliminating titles and abstracts that were the same in IEEE Xplore, Scopus, and ACM databases. After removing duplicate articles, a Full-text review was conducted to obtain the final paper. The full-text review is conducted by thoroughly examining the alignment between the title, abstract, and content as a whole with Peer-to-Peer (P2P) Lending based on blockchain. There are seven papers selected for the final paper, namely X. Zeng *et al*. [29] with the title "A Consortium Blockchain Paradigm on Hyperledger-Based Peer-To-Peer Lending System", N.Arora *et al*. [41] with the title "Blockchain Empowered Framework for Peer to Peer Lending", J. Hartmann *et al*. [42] with the title "A Social-Capital Based Approach to Blockchain-Enabled Peer-To-Peer Lending", W. Uriawan *et al*. [43] with the title "A DApp Architecture for Personal Lending on Blockchain", R. Khara *et al*. [44] with the title "Micro Loans for Farmers", Y.Xie *et al*. [45] with the title "ZeroLender: Trustless Peer-to-Peer Bitcoin Lending Platform" and A. Shukla *et al*. [46] with the title "DeLend: A P2P Loan Management Scheme Using Public Blockchain in 6G Network".

3. RESULTS AND DISCUSSION

3.1. Background

3.1.1. Blockchain

Blockchain is defined as a chain of connected and interlinked digital blocks that serve as an openly distributed ledger [29]. Initially, blockchain was used solely to store transactions of digital currencies, but it later began to be utilized in applications beyond currency and payments [29]. Every transaction recorded on the blockchain is permanent and cannot be deleted. Blockchain technology can also minimize the presence of intermediaries, allowing a transaction to occur in a decentralized manner [31].

The application of blockchain technology was first introduced by Satoshi Nakamoto in 2008 as part of the Bitcoin proposal, a virtual financial system where no central authority is required to issue, transfer, and confirm transactions of the virtual currency, in this case, Bitcoin [31]. After the emergence of Bitcoin, many projects related to blockchain technology surfaced, such as Ethereum [49], Cardano [50], Solana [51], and others. A study in 2018 reported the existence of more than 2,000 software projects based on blockchain technology stored on GitHub [52], and in June 2021, there were more than 90,000 software projects based on blockchain technology stored on GitHub [53].

In the financial field, contracts are a common foundation used for transactions between parties. Contracts in the financial world are typically written on paper and stored by each party. To comprehend blockchain technology, it can be analogized to a digital contract where blockchain technology enables the storage of contracts, transaction records, or other details in digital code, transparently saved in shared databases that protect the data from modifications, deletions, and other detrimental actions [54], [55].

The workings of blockchain can be explained as follows: each transaction is recorded in one block. Each block contains information about the parties involved in the transaction, the transaction time, the quantity of assets transacted, and the conditions for the transaction to occur [56]. The transaction conditions recorded in one block must go through consensus. In a blockchain network, consensus means that the majority of participants must declare that the transaction that occurred is valid [57].

The consensus rules vary for each blockchain network and are generally predetermined by each blockchain network. Once consensus is reached, the transaction is written into a block on the blockchain network, along with a cryptographic hash that acts as a link between blocks. There are various types of consensus mechanisms, such as Proof of Work (PoW) [58], Proof of eXercise (PoX) [59], Practical Byzantine Fault Tolerance (PBFT) [60], RAFT [61], Proof of Luck (PoL) [62], Proof of Elapsed Time (PoET) [29], Proof of Retrievability (POR) [64], Proof of Authority (PoA) [65], and so on. The types of consensus mechanisms depend on the blockchain platform that provides them. After a transaction is recorded in a block, that block cannot be changed or deleted. Each block that has been written also contains the hash information from the previous block. All transactions cannot be altered or manipulated because all participants receive copies of the transactions already recorded in the blockchain network [66].

3.1.2. Peer-to-Peer (P2P) Lending

In Peer-to-Peer (P2P) Lending, there are generally three entities: the borrowers, the lenders, and the Peer-to-Peer (P2P) Lending Platform [29], [67], [29].

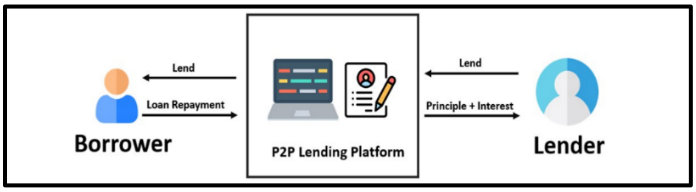

Fig. 3. Mechanism in Peer-to-Peer (P2P) Lending

3.1.2.1. Lender's Mechanism

In the initial stage, the lender needs to register by providing some basic information such as name, email address, the amount of money to invest, and other necessary terms required by the Peer-to-Peer (P2P) lending platform. Different platforms may have varying requirements. After registration and verification by the Peer-to-Peer (P2P) lending platform, the lender can view a list of potential borrowers, usually containing limited information about the borrower's brief profile, the desired loan amount, loan tenure, and other relevant information that the Peer-to-Peer (P2P) lending platform deems necessary to display while maintaining the privacy of the borrower's personal information. Like that shown in Fig. 2, the lender can choose a potential borrower based on personal decisions, knowing that they bear the entire risk resulting from their assessment. After selecting a potential borrower, the lender waits for approval from the borrower to proceed to contract signing. The contract signing can be done online with the Peer-to-Peer (P2P) lending platform as an intermediary. Once the contract is signed, the lender sends the agreed-upon amount to the Peer-to-Peer (P2P) lending platform. The Peer-to-Peer (P2P) lending platform then verifies the transfer. After successful verification, the Peer-to-Peer (P2P) lending platform transfers the money to the borrower. For loan repayment, the borrower sends the repayment amount along with the agreed-upon loan interest to the Peer-to-Peer (P2P) lending platform. The Peer-to-Peer (P2P) lending platform verifies the payment from the borrower. After successful verification, the Peer-to-Peer (P2P) lending platform transfers the money, minus any administrative fees or commissions required by each Peer-to-Peer (P2P) lending platform, to the lender. This process applies to subsequent lender transactions if they wish to transact again [69], [70], [71], [72], [29].

3.1.2.2. Borrower's Mechanism

The mechanism for borrowers is similar to that of lenders. In the initial stage, borrowers register just like lenders do. The required personal information also depends on each Peer-to-Peer (P2P) lending platform. The borrower then provides an application specifying the desired loan amount, loan interest, loan tenure, and sometimes reasons for borrowing or a story about the borrower's financial background. After the loan application is verified and approved by the Peer-to-Peer (P2P) lending platform, the borrower enters the list of potential borrowers, which can be viewed by all lender members. If a lender makes an offer, the borrower receives a notification to either accept or reject the loan offer. If both parties—the borrower and the lender—agree to each other's terms, the contract is signed by the borrower. The borrower receives the required funds from the Peer-to-Peer (P2P) lending platform. Upon the repayment due date, the borrower pays back the borrowed amount along with interest and other agreed-upon fees to the lender through the Peer-to-Peer (P2P) lending platform. The Peer-to-Peer (P2P) lending platform then verifies the repayment and forwards the payment, after deducting administrative fees and commissions determined by the Peer-to-Peer (P2P) lending platform, to the lender [29], [74], [75], [76], [77], **Error! Reference source not found.**[78].

3.1.2.3. Peer-to-Peer (P2P) Lending Platform's Mechanism

The Peer-to-Peer (P2P) lending platform verifies the registration of both lenders and borrowers. The platform can accept or reject registrations from each entity as deemed necessary. The Peer-to-Peer (P2P) lending platform also facilitates the contract-signing process between the borrower and the lender. In some Peer-to-Peer (P2P) lending platforms, both the borrower and the lender can sign the contract with the Peer-to-Peer (P2P) lending platform as an intermediary, but the responsibility for risk remains with each entity. The Peer-to-Peer (P2P) lending platform also facilitates the flow of funds, either from the lender to the borrower during loan disbursement or vice versa from the borrower to the lender during loan repayment, that can be seen in Fig. 2. Peer-to-Peer (P2P) lending platforms typically charge commission and administrative fees from both parties involved in the transactions. These fees are usually deducted directly from the disbursed amount for the borrower or from the repayment amount for the lender. The Peer-to-Peer (P2P) lending platform can also provide assessments for each borrower to evaluate the creditworthiness of the borrower. This assessment is usually displayed in the list of potential borrowers for all lender members. The assessment can be in the form of numerical or alphabetical scores to determine the return rate from the borrower [29], [79], [80], [81].

3.1.3. Peer-to-Peer (P2P) Lending Based on Blockchain

There are several studies on blockchain-based Peer-to-Peer (P2P) lending, such as the one conducted by X. Zeng *et al*. [29], who developed the Hyperledger-based Peer-to-Peer Lending System (HyperP2PLS) based on a consortium blockchain with Hyperledger. There are five entities involved in the Hyperledger-based Peer-to-Peer Lending System (HyperP2PLS): lenders, borrowers, Peer-to-Peer (P2P) Corporation, Peer-to-Peer (P2P) Lending Trading Center, and Banking Regulatory Commission (BRC). N. Arora *et al*. [41] developed a Peer-to-Peer (P2P) Lending Framework with three facilities: smart contract for collateral management, smart contract for loan management, and smart contract for compensation management. This framework allows for forced liquidation due to borrower default events. J. Hartmann *et al*. [42] developed an Ethereum-based platform that provides unsecured loans or a sufficient credit score by calculating creditworthiness using the social capital of borrowers.

W. Uriawan *et al*. [43] developed an Ethereum-based DApp architecture for fully decentralized personal lending to help developers realize their ideas in blockchain application development. The developed architecture uses five components: account management, borrowers and lenders component, API component (wallet), Smart Contract component, and Storage Techniques (blockchain). R. Khara *et al*. [44] developed Mircoloan For Farmers, where loans are secured by agricultural produce. Microloan For Farmers also issues tokens generated or borrowed by farmers that can only be used to purchase agricultural products and repay loans. Y. Xie *et al.* [45] developed the Peer-to-Peer Lending (P2P) Platform Zerolender based on Bitcoin, where borrowers and lenders can interact without direct connection. This system uses three phases: negotiation phase, lending phase, and repayment phase. A. Shukla *et al*. [46] developed DeLend, a Peer-to-Peer (P2P) Lending based on the Ethereum blockchain that reduces repetitive intermediaries from the system with IPFS (InterPlanetary File System) based decentralization and data storage distribution. A. Shukla *et al*. [46] also created an automatic collateral management scheme limited by smart contracts with an end-to-end loan life-cycle model that can be traced.

The background information concerning blockchain, Peer-to-Peer (P2P) lending mechanisms, and related studies on Peer-to-Peer (P2P) lending based on blockchain has been presented. It is crucial to understand these aspects to gain a profound understanding of what blockchain is, how it operates in financial services, how Peer-to-Peer (P2P) Lending works, and the research implementations of blockchain in the field of Peer-to-Peer (P2P) Lending so that the previously outlined research questions can be fully addressed

3.2. What are the characteristics of blockchain that are suitable for Peer-to-Peer (P2P) Lending?

There are several characteristics of blockchain that can be applied to Peer-to-Peer (P2P) Lending, as follows:

1) Decentralization: Decentralization is the primary characteristic of blockchain [82]. In the context of blockchain, decentralization implies the absence of a single participant or central authority governing how transactions take place within the blockchain network. This feature is particularly well-suited for Peer-to-Peer (P2P) lending, as it enables all entities to trust the processes without the dominance of a single entity. Decentralization also facilitates the reduction of intermediaries in Peer-to-Peer (P2P) lending transactions, thereby expediting the lending process [29], [41].

2) Robustness, Anti-Modification & Immutability: One of the characteristics of blockchain is its immutability. A blockchain network must ensure that transactions written into the blockchain cannot be deleted or altered by participants or external parties [83]. Immutability in a blockchain network means that once data is within the blockchain network, it cannot be deleted or altered. In a financial transaction, after the transaction has been validated and recorded in the blockchain network, it becomes unchangeable and immutable. The characteristic of immutability in the blockchain has significant benefits in financial transactions and financial audits because both the sender and receiver of data have evidence that cannot be altered. This characteristic also enhances trust in the blockchain system [29]. It ensures that manipulation is nearly impossible for specific entities, making all processes within the Peer-to-Peer (P2P) Lending system trustworthy for all entities [43].

3) Transparent/ Non-Repudiation: All participants in a blockchain network can have access to the recorded transactions within the blocks, making them transparent to all participants. Digital signatures can be used as proof to ensure non-repudiation of data [84]. Non-repudiation can be translated as, to prevent the denial of information processing, assurance is given that the sender of information is provided with evidence of delivery, and the recipient is provided with evidence of the sender's identity [84]. With this characteristic, trust among participants can be enhanced because each transaction has evidence and cannot be altered [29], [44], [46].

4) Traceability: A blockchain network must be able to facilitate data tracking where participants can trace the origin and destination of a transaction, including a specific date and time. Data traceability also has a significant impact on financial transactions [85], [86]. This characteristic is also suitable when applied to Peer-to-Peer (P2P) lending to prove the transactions that have been conducted by each entity [41], [43], [45].

5) Integrity: Due to the immutability of the blockchain, the data within the blockchain network can be ensured to be secure because it permanently resides within the network with multiple copies across various nodes on the blockchain network. The characteristics of the blockchain itself ensure that the data is highly secure against alterations and maintains its integrity. The aforementioned characteristic, immutability, also guarantees that the blockchain possesses integrity as a characteristic. It can be said that with the integrity of the blockchain network in Peer-to-Peer (P2P) lending, each entity can trust all transactions recorded on the blockchain network [29], [43], [86].

6) Anonymity: Although blockchain are transparent and traceability, on the other hand, it must also be able to protect the identities of participants [88]. Proof of identity can be established through digital signatures from each participant. Some blockchains conceal the original identities of participants using various cryptographic techniques. Many blockchains support the anonymity of participants, meaning their real-world identities. Lenders or borrowers in Peer-to-Peer (P2P) lending want to protect their identities from being disclosed to each other, allowing the characteristic of anonymity to be applied even though all transactions can be transparently visible to all parties [43], [45].

7) Finality & Provenance: Finality and Provenance in blockchain mean that there is only one ledger and shared ledger that provides a unique place to determine ownership of assets or the settlement of a transaction, and provenance facilitates that participants on the network have access to information about where the asset originated and how its ownership can change over time [53], [90]. Ultimately, to ensure that all entities can trust a transaction in Peer-to-Peer (P2P) lending, it is crucial that each transaction is final, cannot be altered under any circumstances, and that all information about the transaction is accessible to all entities.

Therefore, it can be succinctly summarized that the characteristics of blockchain applicable to Peer-to-Peer (P2P) lending encompass decentralization, robustness, anti-modification & immutability, transparency/non-repudiation, traceability, integrity, anonymity, finality, and provenance. Understanding the characteristics of blockchain that align with peer-to-peer lending is necessary for us to discover the benefits of utilizing blockchain.

3.3. What are the benefits of implementing blockchain technology in Peer-to-Peer (P2P) lending?

There are several benefits of utilizing blockchain technology in Peer-to-Peer (P2P) Lending, namely:

1) Enhance Trust: The integration of blockchain in Peer-to-Peer (P2P) lending can enhance transparency and improve trust & traceability [41]. Also, with transparency in the loan application process, trust can be enhanced for lenders, borrowers, and Peer-to-Peer (P2P) lending platform [44]. The use of ZKP (Zero-Knowledge Proofs) [90] in blockchain-based Peer-to-Peer (P2P) Lending can be an alternative to enhance trust. ZKP (Zero-Knowledge Proofs) is a method where one entity can prove to another entity that a given statement is true without revealing any other information, regardless of the fact that the statement is true [45]. Peer-to-Peer (P2P) Lending Platform ZeroLender [45] utilizes Zero-Knowledge Proofs (ZKP) [90], the CoinSwap protocol [91], and Pedersen commitment [92]. ZKP (Zero-Knowledge Proofs) is used in the lending phase, integrated with the CoinSwap protocol to detect if the platform over-collects funds, and in the repayment phase to prove that all repayments are made with the correct amounts [91]. Pedersen commitment [92] is used to ensure the relevance of messages on the Peer-to-Peer (P2P) Lending Platform ZeroLender, such as the investment amount, the repayment amount, and the recipient's payment address. Pedersen Commitment can be described as a cryptographic algorithm that allows one proving entity to verify a value without revealing or altering the value. With a system like the Peer-to-Peer (P2P) Lending Platform ZeroLender, all transactions can be trusted by all entities without knowing the profiles of individual borrowers and lenders or compromising privacy while maintaining transparency.

2) Intermediary, Cost, and Time Reduction: The implementation of smart contracts in blockchain and financial transactions can be applied in real-time, without ambiguity, with lower costs, with better security, and greater transparency, while eliminating intermediaries in the process [44], [46]. This also applies to blockchain-based Peer-to-Peer (P2P) lending, allowing transactions to occur in real time and be immediately known to all entities [41]. The adoption of blockchain in Peer-to-Peer (P2P) lending can also reduce costs by minimizing intermediaries in the process [44]. According to L. Gonzales *et al.* [3], the implementation of blockchain in Peer-to-Peer (P2P) lending, particularly in loan applications, can be carried out without having to navigate the complex settlements and processes of banks. With simplified settlements, the time required for the loan application process will be accelerated. The proposed architecture of the blockchain-based Peer-to-Peer (P2P) lending platform by W. Uriawan *et al.* [43] claims to have better security and lower costs. Entities cannot modify the written contracts unless there is mutual agreement. Additionally, the use of a combination of blockchain networks and client-side applications can reduce the storage space required by borrowers and lenders, thus reducing costs in the Peer-to-Peer (P2P) Lending platform. Cost reduction can also be achieved by storing data on IPFS (InterPlanetary File System) [93], [94]. Blockchain-based Peer-to-Peer (P2P) lending DeLend as proposed by A. Shukla *et al*. [46] stores data on IPFS (InterPlanetary File System), and it can reduce the bandwidth required compared to other networks, making it faster and suitable for future technologies like 6G.

3) Creditworthiness & Default Prevention: The use of smart contracts on the blockchain can also make creditworthiness assessments in Peer-to-Peer (P2P) lending more transparent [42]. The implementation of blockchain in Peer-to-Peer (P2P) lending can also be an alternative in solving the creditworthiness issue of borrowers by using an approach that calculates creditworthiness based on social capital by J.Hartmann *et al*. [42]. The first step is to calculate a score based on the linked accounts. Second, once the value from those accounts is obtained, it is multiplied by the honesty score, which is a value determined by the level of personal information openness from that social media account. Third, there is a bonus variable, which is a value given depending on the consistency of the account, such as when there is a match like the same email address for three social media accounts. The calculated formula will be transparently visible in the blockchain network. The approach of calculating the trust level of borrowers based on social capital has the advantage of not relying on collateral in the form of physical or digital assets or the credit history of borrowers.

In addition to calculating creditworthiness based on social capital, there is also an implementation of creditworthiness assessment on the blockchain conducted by R. Khara *et al*. [44] based on the calculation formula "Microfinance risk analysis using business intelligence" [95], which describes a credit score model for farmers based on their age, marital status, physical condition, income, property status, and the behavior of the farmers in the village where they reside. This implementation allows borrowers to access funds without the need for a prior credit score from banks, microfinance institutions, or other traditional lending organizations.

To prevent default by borrowers, N. Arora *et al*. [41], Y. Xie *et al*. [45] and A. Shukla *et al*. [46] proposes the use of crypto assets as collateral to enhance security in Peer-to-Peer (P2P) lending. N. Arora *et al*. [41] proposed a blockchain-based framework for Peer-to-Peer (P2P) lending that introduces collateral management and compensation management for the first time. This feature allows for a condition where if borrowers miss two consecutive loan payments, either in full or in partial, the collateral will be liquidated by the Peer-to-Peer (P2P) Lending platform and distributed to all lenders who provided loans to those borrowers. The presence of compensation management provides lenders with additional protection against potential defaults by borrowers.

4) Reduce Information Asymmetry: Hyperledger-based Peer-to-Peer Lending System (HyperP2PLS) by X. Zeng *et al*. [29] implement The Peer-to-Peer (P2P) lending Trading Center where information disclosure is effectively regulated, reducing information asymmetry. The problem of information asymmetry between borrowers and lenders can also be significantly reduced by eliminating intermediaries in the process with smart contract [44].

5) Enhance Supervision: In Online Peer-to-Peer (P2P) Lending, there are several problems. One of them is that lenders are highly susceptible to losses due to the bankruptcy of Peer-to-Peer (P2P) lending Platforms and or defaulting borrowers. These conditions make it very difficult for government institutions to supervise and regulate to prevent such occurrences. The implementation of blockchain in Peer-to-Peer (P2P) Lending can enhance government or regulatory supervision, prevention, and enforcement of these issues [29], [96]. Hyperledger-based Peer-to-Peer Lending System (HyperP2PLS) by X. Zeng *et al*. [29] is one of the implementations of blockchain in Peer-to-Peer (P2P) Lending that can enhance the quality of policy by regulatory oversight over lenders, borrowers, and Peer-to-Peer (P2P) Lending platforms.

3.4. What Are The Challenges of Peer-To-Peer (P2P) Lending Based on Blockhchain?

Based on the systematic literature review that has been conducted, it is found that the majority of the concepts offered by the research studies [41], [42], [43], [44] and [46] use the Ethereum blockchain [49]. Research studies [29] use consortium blockhain with Hyperledger, and Zerolender [45] uses Bitcoin blockchain. Ethereum blockchain still has gas fees dependent on the increasing Ethereum price or network traffic, thus incurring significant costs in the Peer-to-Peer (P2P) lending process itself. Although Ethereum is the largest [97], there are still scalability issues [98] and development issues in its ongoing development [99]. As a result, in various studies that use the Ethereum blockchain as the basis for their development, there is still a scarcity of prototype implementations. The scalability concerns arise from the need to accommodate a growing number of participants, transactions, and data within the blockchain network. Similar to Ethereum facing scalability issues, the Bitcoin blockchain also encounters the same problem, where Bitcoin has a size of about 1 MB and produces blocks at a slow rate of only every 10 minutes or so [100], [101]. Therefore, the next challenge in implementing blockchain in Peer-to-Peer (P2P) lending is the prototype implementation. Prototype implementation needs to be carried out to demonstrate that the concept and design can function in a life-cycle process [102]. Testing the prototype helps uncover potential scalability issues and provides insights into how well the system can handle increased demand without compromising performance. By addressing scalability challenges during the prototype phase, researchers can optimize the design and architecture, ultimately contributing to the successful implementation of blockchain in Peer-to-Peer (P2P) lending on a larger scale. The prototype implementation can also demonstrate how blockchain technology can be applied to enhance transparency, security, and efficiency in lending transactions. It allows for the identification of challenges, refinement of the design, and ensures that the proposed system can effectively address the specific needs of Peer-to-Peer (P2P) lending.

Furthermore, there are challenges in implementing blockchain in collateral-based crypto asset Peer-to-Peer (P2P) lending, with the volatility of crypto assets being a significant concern. These assets are not yet stable, making them highly risky as loan collateral. Additionally, the use of crypto assets as the primary currency for loan disbursement and repayment is highly susceptible to fluctuations in the price of the crypto asset itself. This creates the possibility that loans from borrowers may have over-value when converted into fiat currency if there is an extraordinary increase in the price of the crypto asset. Similarly, for lenders, it could result in losses if the value of the crypto asset drops drastically. Volatility in crypto assets is heavily influenced by price manipulation that can be carried out by certain individuals. This is evidenced by the potential manipulation of Bitcoin prices due to large-scale purchases made with tether [103]. Although volatility can be mitigated by issuing own tokens or coins, as done by R. Khara *et al*. [44], deploying tokens in every funding and repayment transaction makes the blockchain network's performance more resource-intensive. Furthermore, the development of infrastructure for private blockchains as well as Layer 2 blockchains [104] cannot be considered easy and cost-effective.

Another challenge lies in the implementation of blockchain technology in peer-to-peer lending, as no research has yet incorporated penalty algorithms for overdue payment behavior. Although there is compensation management by N. Arora *et al*. [41], the penalty for overdue payment itself is not included in the compensation. Compensation is limited to the loan amount and interest only. In practical scenarios, Peer-to-Peer (P2P) lending platforms based on blockchain need to implement penalty algorithms for overdue payments [29], rather than just penalties for payment failures.

Blockchain-based Peer-to-Peer (P2P) lending platforms such as Inlock, Coinloan, BitBond, and BTCPOP [42], [45], [46] face a challenge, specifically the complete delegation of authority to Peer-to-Peer (P2P) lending platforms for managing the assets provided by lenders. This absolute delegation of asset management is highly susceptible to misuse because lenders cannot take any action when there is mishandling of assets by the Peer-to-Peer (P2P) lending platform. Strong supervision is required to prevent potential harm to all entities in Peer-to-Peer (P2P) lending. The differences in regulations among different regulators in various regions remain a challenge in the implementation of blockchain in Peer-to-Peer (P2P) lending involving the role of regulators. The issuance of fiat currencies by blockchain-based Peer-to-Peer (P2P) lending platforms aimed at addressing crypto asset volatility is also a challenge in various countries. Further research is needed to generate effective policies based on the implementation of blockchain in Peer-to-Peer (P2P) lending in countries with significant Peer-to-Peer (P2P) lending transaction volumes.

4. CONCLUSION

In conclusion, the characteristics of blockchain technology offer a compelling foundation for the application of Peer-to-Peer (P2P) lending. The distinct attributes of decentralization, robustness, anti-modification & immutability, transparency/non-repudiation, traceability, integrity, anonymity, and finality & provenance collectively contribute to the trustworthiness, efficiency, and security of Peer-to-Peer (P2P) lending transactions.

The benefits derived from implementing blockchain technology in Peer-to-Peer (P2P) lending are manifold. Firstly, it enhances trust among participants through increased transparency, traceability, and the integration of cryptographic techniques like Zero-Knowledge Proofs. Secondly, it reduces intermediary involvement, resulting in cost and time savings. These advantages serve as a superiority in Peer-to-Peer (P2P) lending when compared to traditional financial institutions that require numerous intermediaries and processes in both application and fund disbursement. Smart contracts play a pivotal role, facilitating real-time, secure, and transparent transactions. Moreover, blockchain applications address creditworthiness concerns by introducing innovative approaches, such as relying on social capital for trust assessment. Additionally, the use of crypto assets as collateral helps prevent defaults, providing security to lenders.

Looking forward, the integration of blockchain technology in Peer-to-Peer (P2P) lending can benefit from focused research and development efforts. Addressing scalability challenges is crucial to enhance transaction throughput and processing speed, ensuring the feasibility of blockchain networks for high-volume Peer-to-Peer (P2P) lending transactions. Optimizing gas fees, particularly in Ethereum-based or Bitcoin based solutions, represents another avenue for cost mitigation and increased cost-effectiveness. Comprehensive prototype implementations of blockchain-based P2P lending platforms are essential to validate concepts and showcase the practicality of proposed solutions.

Furthermore, the absence of penalty algorithms for overdue payments in existing research highlights a critical gap that needs attention. Developing and integrating fair and comprehensive penalty algorithms within blockchain-based Peer-to-Peer (P2P) lending systems is paramount for a robust and balanced approach to handling defaults. Regulatory frameworks also require ongoing exploration to create an environment that supports the unique challenges and opportunities of blockchain-based Peer-to-Peer (P2P) lending, fostering innovation while ensuring user protection.

Infrastructure enhancements, especially for private and Layer 2 blockchains, should be a priority to address current complexities and ensure scalability, security, and efficiency. Exploring advanced cryptographic techniques to balance transaction transparency with user privacy is crucial for maintaining a delicate equilibrium. Additionally, investigating interoperability solutions will facilitate seamless interactions between different blockchain networks, promoting a more connected and versatile Peer-to-Peer (P2P) lending ecosystem.

Based on the conducted studies, it can be concluded that there are many benefits to implementing blockchain technology in Peer-to-Peer (P2P) lending due to the compatibility of blockchain characteristics and benefit that can be applied to Peer-to-Peer (P2P) lending. However, research on the application of blockchain in Peer-to-Peer (P2P) lending is still in the early stages. The limited existing research poses numerous challenges that need to be addressed in the future, necessitating more research on the utilization of blockchain technology in Peer-to-Peer (P2P) lending.

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REFERENCES

[1] P. Schueffel, “Taming the Beast: A Scientific Definition of Fintech,” *Journal of Innovation Management*, vol. 4, no. 4, pp. 32–54, 2017, https://doi.org/10.24840/2183-0606_004.004_0004.

[2] V. Nalluri and L.-S. Chen, “Modelling the FinTech adoption barriers in the context of emerging economies—An integrated Fuzzy hybrid approach,” *Technological Forecasting and Social Change*, vol. 199, pp. 123049–123049, 2024, https://doi.org/10.1016/j.techfore.2023.123049.

[3] J. Liu, Y. Zhang, and J. Kuang, “Fintech development and green innovation: Evidence from China,” *Energy Policy*, vol. 183, p. 113827, 2023, https://doi.org/10.1016/j.enpol.2023.113827.

[4] I. Lee and Y. J. Shin, “Fintech: Ecosystem, business models, investment decisions, and challenges,” *Business Horizons*, vol. 61, no. 1, pp. 35–46, 2018, https://doi.org/10.1016/j.bushor.2017.09.003.

[5] L. Gonzalez, “Blockchain, herding and trust in peer-to-peer lending,” *Managerial Finance*, vol. 46, no. 6, pp. 815-831, 2019, https://doi.org/10.1108/MF-09-2018-0423.

[6] S. Chen, Q. Wang and S. Liu, "Credit Risk Prediction in Peer-to-Peer Lending with Ensemble Learning Framework," *Chinese Control And Decision Conference (CCDC)*, pp. 4373-4377, 2019, https://doi.org/10.1109/CCDC.2019.8832412.

[7] H. Zhao, Y. Ge, Q. Liu, G. Wang, E. Chen, and H. Zhang, “P2P Lending Survey,” *ACM Transactions on Intelligent Systems and Technology*, vol. 8, no. 6, pp. 1–28, 2017, https://doi.org/10.1145/3078848.

[8] K. Kuwabara, C. Horne and D. Anthony, "Trust and Trustworthiness in Online Credit Markets," *IEEE Ninth International Conference on Dependable, Autonomic and Secure Computing,* pp. 974-979, 2011, https://doi.org/10.1109/DASC.2011.161.

[9] M. Flannery, “Kiva and the Birth of Person-to-Person Microfinance,” *Innovations: Technology, Governance, Globalization*, vol. 2, no. 1–2, pp. 31–56, 2007, https://doi.org/10.1162/itgg.2007.2.1-2.31.

[10] S. E. Hartley, “Kiva.org: Crowd-Sourced Microfinance and Cooperation in Group Lending,” S*SRN Electronic Journal,* 2010, https://doi.org/10.2139/ssrn.1572182.

[11] J. Jagtiani, C.Lemieux, "Do fintech lenders penetrate areas that are underserved by traditional banks?," *Journal of Economics and Business*, vol. 100, pp. 43-54, 2018, https://doi.org/10.1016/j.jeconbus.2018.03.001.

[12] T. Fitzpatrick and C. Mues, “How can lenders prosper? Comparing machine learning approaches to identify profitable peer-to-peer loan investments,” *European Journal of Operational Research*, vol. 294, no. 2, pp. 711-722, 2021, https://doi.org/10.1016/j.ejor.2021.01.047.

[13] D. Lanyon, “Exclusive : Zopa Exits Peer-to-Peer Lending,” *altfi,* 2021, [Online]. Available : https://www.altfi.com/article/8608_exclusive-zopa-exits-peer-to-peer-lending.

[14] A. Patwardhan, “Peer-To-Peer Lending,” *Handbook of Blockchain, Digital Finance, and Inclusion*, vol. 1, pp. 389–418, 2018, https://doi.org/10.1016/B978-0-12-810441-5.00018-X.

[15] H. Kholidah, H. Y. Hijriah, I. Mawardi, N. Huda, S. Herianingrum, and B. Alkausar, "A Bibliometric mapping of peer-to-peer lending research based on economic and business perspective," *Heliyon*, vol. 8, no. 11, p. e11512, 2022, https://doi.org/10.1016/j.heliyon.2022.e11512.

[16] R. R. Suryono, I. Budi, and B. Purwandari, "Detection of fintech P2P lending issues in Indonesia," *Heliyon*, vol. 7, no. 4, p. e06782, 2021, https://doi.org/10.1016/j.heliyon.2021.e06782.

[17] H. Bollaert, F. Lopez-de-Silanes, and A. Schwienbacher, "Fintech and Access to Finance," *Journal of Corporate Finance*, vol. 68, p. 101941, 2021, https://doi.org/10.1016/j.jcorpfin.2021.101941.

[18] H. Peng, "The Co-evolution of Chinese Peer-to-Peer Lending Industry and Regulation System," *IEEE Technology & Engineering Management Conference (TEMSCON)*, pp. 1-6, 2019, https://doi.org/10.1109/TEMSCON.2019.8813721.

[19] K. Ren and A. Malik, "Recommendation Engine for Lower Interest Borrowing on Peer to Peer Lending (P2PL) Platform," *IEEE/WIC/ACM International Conference on Web Intelligence (WI)*, pp. 265-269, 2019, https://doi.org/10.1145/3350546.3352528.

[20] M. Klafft, "Online Peer-to-Peer Lending: A Lenders' Perspective," in *Proceedings of the international conference on E-learning, E-business, enterprise information systems, and E-government, EEE*, pp. 371-375, 2008, https://doi.org/10.2139/ssrn.1352352.

[21] S. A. Basha, M. M. Elgammal, and B. M. Abuzayed, "Online peer-to-peer lending: A review of the literature," Electronic Commerce Research and Applications, vol. 48, no. 2, p. 101069, 2021, https://doi.org/10.1016/j.elerap.2021.101069.

[22] J. Foo, L. H. Lim, K. S. W., Wong, "Macroeconomics and Fintech: uncovering latent macroeconomic effects on peer-to-peer lending," *arXiv preprint arXiv:1710.11283*, 2017, https://doi.org/10.48550/arXiv.1710.11283.

[23] J. Li, "Thinking about Internet Finance," *Management World*, no. 7, pp. 90-91, 2015, https://doi.org/10.19744/j.cnki.11-1235/f.2015.07.002.

[24] Y. Jin and Y. Zhu, "A Data-Driven Approach to Predict Default Risk of Loan for Online Peer-to-Peer (P2P) Lending," *Fifth International Conference on Communication Systems and Network Technologies*, pp. 609-613, 2015, https://doi.org/10.1109/CSNT.2015.25.

[25] R. R. Suryono, I. Budi, and B. Purwandari, "Challenges and Trends of Financial Technology (Fintech): A Systematic Literature Review," *Information*, vol. 11, no. 12, p. 590, 2020, https://doi.org/10.3390/info11120590.

[26] J. Wang and R. Li, "Asymmetric information in peer-to-peer lending: empirical evidence from China," *Finance Research Letters*, vol. 51, p. 103452, 2023, https://doi.org/10.1016/j.frl.2022.103452.

[27] Y. Sha, "Rating manipulation and creditworthiness for platform economy: Evidence from peer-to-peer lending," *International Review of Financial Analysis*, vol. 84, p. 102393, 2022, https://doi.org/10.1016/j.irfa.2022.102393.

[28] Y. Zhang, H. Li, M. Hai, J. Li, and A. Li, "Determinants of loan funded successful in online P2P Lending," *Procedia Computer Science*, vol. 122, pp. 896–901, 2017, https://doi.org/10.1016/j.procs.2017.11.452.

[29] "The 2nd Global Alternative Finance Market Benchmarking Report - CCAF publications," *Cambridge Judge Business School*, 2021, [Online]. Available : https://www.jbs.cam.ac.uk/faculty-research/centres/alternative-finance/publications/the-2nd-global-alternative-finance-market-benchmarking-report

[30] Y. Zhang, H. Li, M. Hai, J. Li, and A. Li, "Determinants of loan funded successful in online P2P Lending," *Procedia Computer Science*, vol. 122, pp. 896–901, 2017, https://doi.org/10.1016/j.procs.2017.11.452.

[31] S. Nakamoto, "Bitcoin: A peer-to-peer electronic cash system," 2008, [Online]. Available : https://bitcoin.org/bitcoin.pdf

[32] Y. Zhu, "Research on Digital Finance Based on Blockchain Technology," *International Conference on Computer, Blockchain and Financial Development (CBFD)*, pp. 410-414, 2021, https://doi.org/10.1109/CBFD52659.2021.00089.

[33] H. A. Almahadin, M. Shehadeh, A. S. Al-Gasaymeh, I. A. Abu-AlSondos and A. A. B. Atta, "Impact of Blockchain Technology and Fintech on Sustainable Performance," *International Conference on Business Analytics for Technology and Security (ICBATS)*, pp. 1-5, 2023, https://doi.org/10.1109/ICBATS57792.2023.10111313.

[34] B. Karadag, A. Akbulut and A. H. Zaim, "A Review on Blockchain Applications in Fintech Ecosystem," *International Conference on Advanced Creative Networks and Intelligent Systems (ICACNIS)*, pp. 1-5, 2022, https://doi.org/10.1109/ICACNIS57039.2022.10054910.

[35] Y. Song, C. Sun, L. Li, F. Wei, Y. Liu and B. Sun, "Research on Blockchain-Based FinTech Trust Evaluation Mechanism," in *IEEE Access*, vol. 11, pp. 83615-83626, 2023, https://doi.org/10.1109/ACCESS.2023.3301340.

[36] S. Rashmitha, H. A. Sanjay, K. A. Shastry and K. J. S. Laxmi, "FarmFund - A Blockchain based Crowdfunding App for Farmers," *7th International Conference on Communication and Electronics Systems (ICCES)*, pp. 682-689, 2022, https://doi.org/10.1109/ICCES54183.2022.9835829.

[37] L. Cocco, A. Pinna, and M. Marchesi, "Banking on Blockchain: Costs Savings Thanks to the Blockchain Technology," *Future Internet*, vol. 9, no. 3, p. 25, 2017, https://doi.org/10.3390/fi9030025.

[38] M. Al-Qahtani and S. Ahmed, "Blockchain Application in Banking System: Saudi Arabian Perspective," *International Conference on Advancement in Computation & Computer Technologies (InCACCT),* pp. 1-5, 2023, https://doi.org/10.1109/InCACCT57535.2023.10141779.

[39] V. Chang, P. Baudier, H. Zhang, Q. Xu, J. Zhang, and M. Arami, "How Blockchain can impact financial services – The overview, challenges and recommendations from expert interviewees," *Technological Forecasting and Social Change*, vol. 158, no. 1, p. 120166, 2020, https://doi.org/10.1016/j.techfore.2020.120166.

[40] X. Zeng, N. Hao, J. Zheng and X. Xu, "A consortium blockchain paradigm on hyperledger-based peer-to-peer lending system," *in China Communications*, vol. 16, no. 8, pp. 38-50, 2019, https://doi.org/10.23919/JCC.2019.08.004.
[41] N. Arora and P. D. Kaur, "Blockchain Empowered Framework for Peer to Peer Lending," *9th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO)*, pp. 1-5, 2021, https://doi.org/10.1109/ICRITO51393.2021.9596552.
[42] J. Hartmann and O. Hasan, "A social-capital based approach to blockchain-enabled peer-to-peer lending," *Third International Conference on Blockchain Computing and Applications (BCCA),* pp. 105-110, 2021, https://doi.org/10.1109/BCCA53669.2021.9656964.
[43] W. Uriawan, A. Wahana, C. Slamet and V. Suci Asih, "A DApp Architecture for Personal Lending on Blockchain," *7th International Conference on Wireless and Telematics (ICWT)*, pp. 1-6, 2021, https://doi.org/10.1109/ICWT52862.2021.9678397.
[44] R. Khara, D. Pomendkar, R. Gupta, I. Hingorani and D. Kalbande, "Micro Loans for Farmers," *11th International Conference on Computing, Communication and Networking Technologies (ICCCNT)*, pp. 1-5, 2020, https://doi.org/10.1109/ICCCNT49239.2020.9225577.
[45] Y. Xie, J. Holmes, and G. G. Dagher, ”ZeroLender: Trustless Peer-to-Peer Bitcoin Lending Platform,” *in Proceedings of the Tenth ACM Conference on Data and Application Security and Privacy (CODASPY)*, pp. 247–258, 2020, https://doi.org/10.1145/3374664.3375735.
[46] A. Shukla, M. Nankani, S. Tanwar, N. Kumar and M. J. Piran, "DeLend: A P2P Loan Management Scheme Using Public Blockchain in 6G Network," *ICC - IEEE International Conference on Communications*, pp. 1-6, 2021, https://doi.org/10.1109/ICC42927.2021.9500542.
[47] M. N. M. Bhutta *et al*., "A Survey on Blockchain Technology: Evolution, Architecture and Security," *in IEEE Access*, vol. 9, pp. 61048-61073, 2021, https://doi.org/10.1109/ACCESS.2021.3072849.
[48] M. Swan. *Blockchain : blueprint for a new economy*. *O'Reilly Media, Inc*., 2015, https://books.google.co.id/books?hl=id&lr=&id=RHJmBgAAQBAJ.
[49] V. Buterin, “A next-generation smart contract and decentralized application platform,” *white paper*, vol. 3, no. 37, 2014, https://finpedia.vn/wp-content/uploads/2022/02/Ethereum_white_paper-a_next_generation_smart_contract_and_decentralized_application_platform-vitalik-buterin.pdf.
[50] S. Barac, I. Botički, G. Perković, V. Radošević and I. Terzić, "Cardano - What Is It and How to Start Working with It," *46th MIPRO ICT and Electronics Convention (MIPRO)*, pp. 1727-1732, 2023, https://doi.org/10.23919/MIPRO57284.2023.10159944.
[51] G. A. Pierro and R. Tonelli, "Can Solana be the Solution to the Blockchain Scalability Problem?," *IEEE International Conference on Software Analysis, Evolution and Reengineering (SANER)*, pp. 1219-1226, 2022, https://doi.org/10.1109/SANER53432.2022.00144.
[52] M. Fahmideh *et al*., “Engineering Blockchain-based Software Systems: Foundations, Survey, and Future Directions,” *ACM Computing Surveys*, vol. 55, no. 6, pp. 1–44, 2022, https://doi.org/10.1145/3530813.
[53] M. Kassab, "Exploring Non-Functional Requirements for Blockchain-Oriented Systems," *IEEE 29th International Requirements Engineering Conference Workshops (REW)*, pp. 216-219, 2021, https://doi.org/10.1109/REW53955.2021.00040.
[54] M. Iansiti and K. Lakhani, “The Truth About Blockchain,” *Harvard Business Review*, vol. 95, no. 1, pp. 118-127, 2018, https://hbr.org/2017/01/the-truth-about-blockchain.
[55] K. Saini, A. Roy, P. R. Chelliah and T. Patel, "Blockchain 2.O: A Smart Contract," *International Conference on Computational Performance Evaluation (ComPE)*, pp. 524-528, 2021, https://doi.org/10.1109/ComPE53109.2021.9752021.
[56] V. Gatteschi, F. Lamberti, C. Demartini, C. Pranteda and V. Santamaría, "To Blockchain or Not to Blockchain: That Is the Question," *in IT Professional*, vol. 20, no. 2, pp. 62-74, 2018, https://doi.org/10.1109/MITP.2018.021921652.
[57] S. Pahlajani, A. Kshirsagar and V. Pachghare, "Survey on Private Blockchain Consensus Algorithms," *1st International Conference on Innovations in Information and Communication Technology (ICIICT)*, pp. 1-6, 2019, https://doi.org/10.1109/ICIICT1.2019.8741353.
[58] S. Yan, "Analysis on Blockchain Consensus Mechanism Based on Proof of Work and Proof of Stake," *International Conference on Data Analytics, Computing and Artificial Intelligence (ICDACAI)*, pp. 464-467, 2022, https://doi.org/10.1109/ICDACAI57211.2022.00098.
[59] A. Shoker, "Sustainable blockchain through proof of exercise," *IEEE 16th International Symposium on Network Computing and Applications (NCA)*, pp. 1-9, 2017, https://doi.org/10.1109/NCA.2017.8171383.
[60] M. Castro and B. Liskov, “Practical byzantine fault tolerance and proactive recovery,” *ACM Transactions on Computer Systems*, vol. 20, no. 4, pp. 398–461, 2002, https://doi.org/10.1145/571637.571640.
[61] S. Pahlajani, A. Kshirsagar and V. Pachghare, "Survey on Private Blockchain Consensus Algorithms," *1st International Conference on Innovations in Information and Communication Technology (ICIICT)*, pp. 1-6, 2019, https://doi.org/10.1109/ICIICT1.2019.8741353.
[62] M. Milutinovic, W. He, H. Wu, and M. Kanwal, “An Improved-PoA Consensus Algorithm for Blockchain-empowered Data Sharing System,” *Proceedings of the 1st Workshop on System Software for Trusted Execution*, pp. 1-6, 2016, https://doi.org/10.1145/3007788.3007790.
[63] L. Chen, L. Xu, N. Shah, Z. Gao, Y. Lu, and W. Shi, “On Security Analysis of Proof-of-Elapsed-Time (PoET),” *Lecture Notes in Computer Science*, pp. 282–297, 2017, https://doi.org/10.1007/978-3-319-69084-1_19.

[64] K. D. Bowers, A. Juels, and A. Oprea, “Proofs of retrievability: Theory and implementation,” *Proceedings of the ACM workshop on Cloud computing security - CCSW*, pp. 43-54, 2009, https://doi.org/10.1145/1655008.1655015.

[65] J. Song, F. Bai, Y. Zhu, T. Shen, and A. Xie, “An Improved-PoA Consensus Algorithm for Blockchain-empowered Data Sharing System,” *in Proceedings of the 4th Blockchain and Internet of Things Conference,* pp. 128-134, 2022, https://doi.org/10.1145/3559795.3559813.

[66] R. Zhou and Z. Lin, "A Privacy Protection Scheme for Permissioned Blockchain Based on Trusted Execution Environment," *International Conference on Blockchain Technology and Information Security (ICBCTIS),* pp. 1-4, 2022, https://doi.org/10.1109/ICBCTIS55569.2022.00012.

[67] F. Tan, X. Hou, J. Zhang, Z. Wei and Z. Yan, "A Deep Learning Approach to Competing Risks Representation in Peer-to-Peer Lending," *in IEEE Transactions on Neural Networks and Learning Systems*, vol. 30, no. 5, pp. 1565-1574, 2019, https://doi.org/10.1109/TNNLS.2018.2870573.

[68] A. Milne and P. Parboteeah, “The Business Models and Economics of Peer-to-Peer Lending,” *SSRN Electronic Journal*, no. 17, 2016, https://doi.org/10.2139/ssrn.2763682.

[69] Y. Xia, C. Liu, and N. Liu, “Cost-sensitive boosted tree for loan evaluation in peer-to-peer lending,” *Electronic Commerce Research and Applications*, vol. 24, pp. 30–49, 2017, https://doi.org/10.1016/j.elerap.2017.06.004.

[70] C. Wang, J. Wang, C. Wu, and Y. Zhang, “Voluntary Disclosure in P2p Lending: Information or Hyperbole?,” *Social Science Research Network*, vol. 79, p. 102024, 2022, https://doi.org/10.2139/ssrn.4292923.

[71] H. Liu, H. Qiao, S. Wang, and Y. Li, “Platform Competition in Peer-to-Peer Lending Considering Risk Control Ability,” *European Journal of Operational Research*, vol. 274, no. 1, pp. 280–290, 2019, https://doi.org/10.1016/j.ejor.2018.09.024.

[72] S. Chen, Y. Gu, Q. Liu, and Y. Tse, “How do lenders evaluate borrowers in peer-to-peer lending in China?,” *International Review of Economics & Finance*, vol. 69, pp. 651–662, 2020, https://doi.org/10.1016/j.iref.2020.06.038.

[73] R. R. Suryono, B. Purwandari, and I. Budi, “Peer to Peer (P2P) Lending Problems and Potential Solutions: A Systematic Literature Review,” *Procedia Computer Science*, vol. 161, pp. 204–214, 2019, https://doi.org/10.1016/j.procs.2019.11.116.

[74] J. Ding, J. Huang, Y. Li, and M. Meng, “Is there an effective reputation mechanism in peer-to-peer lending? Evidence from China,” *Finance Research Letters*, vol. 30, pp. 208–215, 2019, https://doi.org/10.1016/j.frl.2018.09.015.

[75] B. Wu, Z. Liu, Q. Gu, and F.-S. Tsai, “Underdog mentality, identity discrimination and access to peer-to-peer lending market: Exploring effects of digital authentication,” *Journal of International Financial Markets, Institutions and Money*, vol. 83, p. 101714, 2023, https://doi.org/10.1016/j.intfin.2022.101714.

[76] Z. Liu, J. Shang, S. Wu, and P. Chen, “Social collateral, soft information and online peer-to-peer lending: A theoretical model,” *European Journal of Operational Research*, vol. 281, no. 2, pp. 428-438, 2019, https://doi.org/10.1016/j.ejor.2019.08.038.

[77] H. Yum, B. Lee, and M. Chae, “From the wisdom of crowds to my own judgment in microfinance through online peer-to-peer lending platforms,” *Electronic Commerce Research and Applications*, vol. 11, no. 5, pp. 469–483, 2012, https://doi.org/10.1016/j.elerap.2012.05.003.

[78] S. Cai, X. Lin, D. Xu, and X. Fu, “Judging online peer-to-peer lending behavior: A comparison of first-time and repeated borrowing requests,” *Information & Management*, vol. 53, no. 7, pp. 857–867, 2016, https://doi.org/10.1016/j.im.2016.07.006.

[79] B. Ma, Z. Zhou, and F. Hu, “Pricing mechanisms in the online Peer-to-Peer lending market,” *Electronic Commerce Research and Applications*, vol. 26, pp. 119–130, 2017, https://doi.org/10.1016/j.elerap.2017.10.006.

[80] J. Jiang, L. Liao, Z. Wang, and X. Zhang, “Government affiliation and peer-to-peer lending platforms in China,” *Journal of Empirical Finance*, vol. 62, pp. 87-106, 2021, https://doi.org/10.1016/j.jempfin.2021.02.004.

[81] G.-X. Gao, Z.-P. Fan, X. Fang, and Y. F. Lim, “Optimal Stackelberg strategies for financing a supply chain through online peer-to-peer lending,” *European Journal of Operational Research*, vol. 267, no. 2, pp. 585–597, 2018, https://doi.org/10.1016/j.ejor.2017.12.006.

[82] M. Sigwart, P. Frauenthaler, C. Spanring, M. Sober and S. Schulte, "Decentralized Cross-Blockchain Asset Transfers," *Third International Conference on Blockchain Computing and Applications (BCCA)*, pp. 34-41, 2021, https://doi.org/10.1109/BCCA53669.2021.9657007.

[83] P. Shen *et al*., "A Survey on Safety Regulation Technology of Blockchain Application and Blockchain Ecology," *IEEE International Conference on Blockchain (Blockchain)*, pp. 494-499, 2022, https://doi.org/10.1109/Blockchain55522.2022.00076.

[84] A. Narayanan, *Bitcoin and cryptocurrency technologies: a comprehensive introduction*. Princeton University Press, 2016, https://books.google.co.id/books?id=LchFDAAAQBAJ&lr=&hl=id&source=gbs_navlinks_s.

[85] Z. Zheng, S. Xie, H. Dai, X. Chen and H. Wang, "An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends," *IEEE International Congress on Big Data (BigData Congress)*, pp. 557-564, 2017, https://doi.org/10.1109/BigDataCongress.2017.85.

[86] M. Bellucci, D. Cesa Bianchi, and G. Manetti, “Blockchain in accounting practice and research: systematic literature review,” *Meditari Accountancy Research*, vol. 30, no. 7, pp. 121–146, 2022, https://doi.org/10.1108/medar-10-2021-1477.

[87] K. -B. Yue, "Assuring Referential Integrity in Blockchain Applications," *Fourth International Conference on Blockchain Computing and Applications (BCCA)*, pp. 47-54, 2022, https://doi.org/10.1109/BCCA55292.2022.9921976.

[88] Y. Zhou, J. Wu and S. Zhang, "Anonymity Analysis of Bitcoin, Zcash and Ethereum," *IEEE 2nd International Conference on Big Data, Artificial Intelligence and Internet of Things Engineering (ICBAIE)*, pp. 45-48, 2021, https://doi.org/10.1109/ICBAIE52039.2021.9389894.

[89] R. A. Das, M. M. S. Pahalovi and M. N. Yanhaona, "Transaction Finality through Ledger Checkpoints," *IEEE 25th International Conference on Parallel and Distributed Systems (ICPADS)*, pp. 183-192, 2019, https://doi.org/10.1109/ICPADS47876.2019.00036.

[90] S. Goldwasser, S. Micali, and C. Rackoff, "The knowledge complexity of interactive proof-systems," Proceedings of the seventeenth annual ACM symposium on Theory of computing - STOC, pp. 203-225, 1985, https://doi.org/10.1145/22145.22178.

[91] M.Gregory, "CoinSwap: Transaction graph disjoint trustless trading," *bitcointalk.org*, 2013, [Online]. Available : https://bitcointalk.org/index.php?topic=321228.0.

[92] T. P. Pedersen, "Non-Interactive and Information-Theoretic Secure Verifiable Secret Sharing," *Advances in Cryptology — CRYPTO*, pp. 129–140, 1991, https://doi.org/10.1007/3-540-46766-1_9.

[93] J. Benet, "IPFS - Content Addressed, Versioned, P2P File System," *arXiv.org*, 2014, https://arxiv.org/abs/1407.3561.

[94] R. Kumar and R. Tripathi, "Implementation of Distributed File Storage and Access Framework using IPFS and Blockchain," *Fifth International Conference on Image Information Processing (ICIIP)*, pp. 246-251, 2019, https://doi.org/10.1109/ICIIP47207.2019.8985677.

[95] T. Hajji, S. Y. El Jasouli, J. Mbarki and E. M. Jaara, "Microfinance risk analysis using the business intelligence," 4th *IEEE International Colloquium on Information Science and Technology (CiSt),* vol. 3, pp. 675-680, 2016, https://doi.org/10.1109/CIST.2016.7804971.

[96] W. Yan and W. Zhou, "Is blockchain a cure for peer-to-peer lending?," *Annals of Operations Research*, vol. 321, no. 1-2, pp. 693-716, 2022, https://doi.org/10.1007/s10479-022-05108-1.

[97] Z. Li, "Analysis on the Development of Ethereum and Its Consensus Mechanisms," *International Conference on Data Analytics, Computing and Artificial Intelligence (ICDACAI)*, pp. 196-199, 2022, https://doi.org/10.1109/ICDACAI57211.2022.00047.

[98] M. Bez, G. Fornari and T. Vardanega, "The scalability challenge of ethereum: An initial quantitative analysis," *IEEE International Conference on Service-Oriented System Engineering (SOSE)*, pp. 167-176, 2019, https://doi.org/10.1109/SOSE.2019.00031.

[99] C. G. Harris, "The Risks and Challenges of Implementing Ethereum Smart Contracts," *IEEE International Conference on Blockchain and Cryptocurrency (ICBC)*, pp. 104-107, 2019, https://doi.org/10.1109/BLOC.2019.8751493.

[100] S. Shirodkar, K. Kulkarni, R. Khanjode, S. Kohle, P. Deshmukh and P. Patil, "Layer 2 Solutions to Improve the Scalability of Blockchain," *5th International Conference on Advances in Science and Technology (ICAST)*, pp. 54-57, 2022, https://doi.org/10.1109/ICAST55766.2022.10039486.

[101] M. Memon, S. S. Hussain, U. A. Bajwa and A. Ikhlas, "Blockchain Beyond Bitcoin: Blockchain Technology Challenges and Real-World Applications," *International Conference on Computing, Electronics & Communications Engineering (iCCECE)*, pp. 29-34, 2018, https://doi.org/10.1109/iCCECOME.2018.8658518.

[102] V. Aulia and S. Yazid, "Review of Blockchain Application in Education Data Management," *2nd International Conference on Smart Computing and Electronic Enterprise (ICSCEE)*, pp. 95-101, 2021, https://doi.org/10.1109/ICSCEE50312.2021.9497997.

[103] J. M. Griffin and A. Shams, "Is Bitcoin Really Untethered?," *The Journal of Finance*, vol. 75, no. 4, 2020, https://doi.org/10.1111/jofi.12903.

[104] S. Shirodkar, K. Kulkarni, R. Khanjode, S. Kohle, P. Deshmukh and P. Patil, "Layer 2 Solutions to Improve the Scalability of Blockchain," *5th International Conference on Advances in Science and Technology (ICAST),* , pp. 54-57, 2022, https://doi.org/10.1109/ICAST55766.2022.10039486.

BIOGRAPHY OF AUTHORS

Timotius Victory, is continuing his postgraduate education at the Master of Computer Science at Universitas Indonesia in 2019. Email: timotius.victory@ui.ac.id.

Setiadi Yazid, is a senior lecturer and researcher at the Faculty of Computer Science at Universitas Indonesia. Email: setiadi@cs.ui.ac.id.