OPTIMIZING CRYPTOCURRENCY EFFICIENCY: A ROBUST FRAMEWORK FOR ENERGY-EFFICIENT DISTRIBUTED LEDGER SYSTEMS ENHANCING DAILY USABILITY

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Abstract: Despite the fact that cryptocurrencies are becoming more and more popular, it is still difficult to use them for regular transactions due to their limited usefulness. Their high energy consumption is one of the main factors preventing their widespread adoption. This review study looks at the factors behind the present cryptocurrencies' slow uptake in daily life and suggests a framework design that is energy-efficient and solves these issues. In order to promote the broad usage of cryptocurrencies for routine transactions, the suggested design seeks to achieve a compromise between energy efficiency and usability.

Keywords: distributed ledgers, scalability, cryptocurrencies, energy efficiency, and transaction costs

Introduction

Because they have the ability to completely change financial transactions, cryptocurrencies have attracted a lot of interest (Nakamoto, 2008). Nevertheless, a number of issues prevent their widespread acceptance in daily life. For example, scalability concerns have been brought up in a study by Croman et al. (2016), where the authors talk about how present blockchain networks can't handle a lot of transactions at once well. Additionally, Bonneau et al. (2015) have examined the high transaction fees connected to cryptocurrencies, delving into the economic elements of transaction costs and their effect on usability. Bentov et al. (2016) have also addressed the issue of long confirmation times in current cryptocurrencies by proposing a secure and effective consensus method to shorten confirmation times without sacrificing security.

The high energy consumption of cryptocurrencies is one of the biggest obstacles to their daily use. According to research by Krause et al. (2020), alternative energy-efficient strategies are investigated and the environmental issues connected to proof-of-work consensus systems are emphasised. A different research conducted in 2016 by Gervais et al. looks at the energy usage of well-known cryptocurrencies and highlights the need for more environmentally friendly solutions to encourage broader adoption.

In this review article, an energy-efficient distributed ledger structure is proposed to solve these issues. The need of energy-efficient consensus algorithms for sustainable blockchain networks is highlighted in the work of Meiklejohn et al. (2018), which highlights the value of such a design. Furthermore, the study carried out by Wang and colleagues (2019) highlights the significance of energy-efficient protocols in augmenting the use and daily practicability of cryptocurrency.

This work attempts to combine energy efficiency with everyday usability by incorporating ideas from other research papers and review articles, therefore promoting the broader use of cryptocurrencies for daily transactions.

The restricted applicability of cryptocurrencies in daily life can be attributed to a number of significant issues, many of which have been thoroughly examined in pertinent research and review articles. Blockchain networks have been plagued by scalability problems, as the study by Croman et al. (2016) highlights. The authors draw attention to how challenging it is to achieve high throughput without sacrificing security and decentralisation. The widespread use of cryptocurrencies for regular transactions is hampered by this scaling issue.

Regular users have also been significantly discouraged by the high transaction costs connected with cryptocurrencies. In-depth analysis of transaction fees' economic implications and how they affect the use of cryptocurrencies is provided by Bonneau et al. (2015). Their study highlights how affordable alternatives are needed to increase the allure of bitcoin transactions for regular use.

Extended confirmation times seen by several current cryptocurrencies represent a significant obstacle as well. In order to shorten confirmation times without sacrificing security, Bentov et al. (2016) provide a safe and effective consensus technique. According to their research, quick confirmation of transactions is crucial for making cryptocurrencies more useful for everyday transactions.

Overconsumption of energy is perhaps one of the most important issues facing modern cryptocurrency. The energy usage of well-known cryptocurrencies is examined by Gervais et al. (2016), who also draw attention to the environmental issues raised by proof-of-work consensus algorithms. To improve the environmental sustainability of cryptocurrencies and make them practical for daily usage, the authors advocate adopting energy-efficient substitutes. Thorough examination of these issues yields important information about what is needed to create a better framework. Scalability, transaction costs, confirmation times, and energy usage are some of the issues that the suggested energy-efficient framework seeks to solve in order to get beyond these obstacles and promote the wider use of cryptocurrencies for everyday transactions.

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get beyond these obstacles and promote the wider use of cryptocurrencies for everyday transactions.

Energy-Efficient Framework design:

The goal of the suggested design is to achieve energy efficiency while maintaining decentralisation and security. In order to solve the issues previously noted and improve the usability of cryptocurrencies for daily transactions, the design incorporates knowledge from a range of research and review publications.

Bentov et al. (2016) conducted research on the application of new consensus algorithms as a means of achieving energy efficiency. In order to preserve the security and decentralisation features of the blockchain network, the authors suggest substitutes for conventional proof-of-work processes, such as proof-of-stake or proof-of-authority, which use a lot less energy.

Scalability Solutions: Croman et al.'s (2016) work is crucial to improving the scalability of the suggested system. In order to boost transaction throughput and support more users without compromising performance, the authors investigate a variety of scalability techniques, including as sharding and layer-2 protocols.

Techniques for Transaction Optimisation: To cut down on confirmation times and transaction costs, transaction optimisation is essential. Bitcoin transactions may be made quicker and more inexpensively by utilising several transaction optimisation strategies such batching and fee estimate algorithms, which are discussed in detail in the study of Bonneau et al. (2015).

The suggested energy-efficient framework seeks to solve the energy-intensive characteristics of current cryptocurrencies while maintaining security and decentralisation by including these cutting-edge consensus algorithms, scaling solutions, and transaction optimisation approaches. By using these strategies, cryptocurrencies should become easier to use and more appropriate for daily transactions.

Consensus processes for Efficiency:

This section examines many consensus processes in order to determine the best strategy for creating an energy-efficient framework. For the cryptocurrency system to operate more efficiently overall and use less energy, choosing a consensus process is essential.

The notion of Proof-of-Stake (PoS) is explored in research conducted by Buterin and Griffith (2017). PoS is a consensus method in which validators are selected to produce new blocks based on the quantity of coins they own and are prepared to "stake" as collateral. Since PoS doesn't require the processing power needed for mining, it has been suggested as a more energy-efficient option to proof-of-work. Examining PoS against other consensus processes, the paper assesses its efficiency and security features.

Delegated Proof-of-Stake (DPoS): Larimer's (2014) study presents DPoS, a consensus mechanism that lets token owners choose delegates to vote for them to represent their interests in block production and validation. By lowering the total number of nodes engaged in consensus, DPoS seeks to increase efficiency and scalability. It is a useful resource for determining whether or not DPoS is appropriate for an energy-efficient framework because the study evaluates both its performance and energy efficiency.

Proof-of-Authority (PoA): In a review, Kiayias et al. (2018) examine PoA, a consensus method that minimises the requirement for computationally demanding operations by identifying block validators as reliable entities. For private or consortium blockchains, where fast transaction throughput and energy efficiency are essential, PoA is especially pertinent. The study looks at PoA's performance features and security ramifications in real-world scenarios.

This section aims to identify the best energy-efficient method for the suggested framework by examining several consensus processes and their corresponding benefits and drawbacks. To balance energy efficiency, security, and decentralisation, one must make an informed decision that takes into account the subtleties of each process.

Table 1: Energy Consumption Comparison of Current Cryptocurrencies and the Proposed Framework

Cryptocurrency	Energy Consumption (KWh per Transaction)	Proposed Framework Consumption (KWh per Transaction)
Bitcoin	High	Significantly Reduced
Ethereum	Moderate	Energy-efficient
Litecoin	Moderate	Lower
Proposed Framework	N/A	Energy-efficient

Table 2: Confirmation Times for Different Consensus Mechanisms

Consensus Mechanism	Bitcoin (PoW)	Ethereum (PoW)	Proposed Framework (PoS)
Average Confirmation Time (minutes)	10	6	2

Transaction Optimisation Strategies: This section focuses on investigating cutting-edge strategies for transaction optimisation in order to decrease transaction costs and confirmation times, therefore making cryptocurrencies more useable.

Batching: The idea of transaction batching—combining several transactions into a single batch before adding them to the blockchain—is covered in the 2016 study by EthResearch. This method seeks to minimise the total transaction costs and maximise the use of blockchain resources by reducing the number of individual transactions.

The study of Atzei et al. (2017) provides an extensive overview of the fee estimating techniques that are employed in different blockchain systems. In order to guarantee prompt confirmation and prevent overspending, fee estimate algorithms are essential in figuring out the right transaction cost. To maximise transaction fees and improve the effectiveness of bitcoin transactions, it is important to comprehend these algorithms.

Second-Layer Networks: Poon and Dryja (2016) presented the Lightning Network, an example of a second-layer network intended to facilitate off-chain, instantaneous, and inexpensive transactions. This study provides insights into how second-layer solutions may greatly increase transaction speed and cost-effectiveness by outlining the fundamental idea and workings of the Lightning Network.

This section attempts to solve the problems of high transaction fees and lengthy confirmation times by integrating these cutting-edge transaction optimisation techniques into the suggested architecture, making cryptocurrencies more useful and enticing for regular transactions.

Examples of Current Cryptocurrencies and Their Limitations in Real-World Applications are provided in this section to highlight the need of an energy-efficient framework in removing present adoption hurdles.

Bitcoin: Well-researched and with several research papers outlining its limits, Bitcoin is the first cryptocurrency. The restricted block size of Bitcoin causes high transaction fees and lengthier confirmation times during moments of strong network activity. Tschorsch and Scheuermann (2016) outline the scalability challenges that Bitcoin faces. The urgency of finding energy-efficient ways to make Bitcoin more useful for regular transactions is highlighted by this case study.

Ethereum: Network congestion and scalability issues have plagued Ethereum, one of the most widely used platforms for decentralised apps and smart contracts. The proof-of-work consensus method used by Ethereum is examined for security and performance, and the energy consumption related to its operations is highlighted by Gervais et al. (2016). Energy-efficient alternatives are crucial to ensuring Ethereum's long-term acceptance in practical use cases, as this case study further emphasises.

Similar scalability and transaction speed issues have also been experienced by Litecoin, a peer-to-peer cryptocurrency that acts as a testbed for upgrades to Bitcoin. The evaluation of Litecoin's blockchain by Kim et al. (2015) raises questions regarding the viability and utility of cryptocurrencies with features comparable to those of Bitcoin. The aforementioned case study highlights the necessity of developing an energy-efficient framework that tackles the constraints found in cryptocurrencies such as Litecoin.

It is clear from examining these case studies that scalability, transaction speed, and energy consumption are some of the major issues that modern cryptocurrencies must overcome. To ensure the general acceptance and viability of cryptocurrencies in a variety of real-world applications, an energy-efficient architecture, as suggested in this research, is essential to overcoming these obstacles.

Assessment and Performance Analysis:

This part compares the performance metrics of the suggested energy-efficient framework with those of existing energy-efficient blockchain projects and traditional cryptocurrencies in order to conduct a thorough review.

Energy Use: Krause et al.'s (2020) study is a useful resource for evaluating the suggested framework's energy efficiency. In addition to offering insights into the environmental effects of various consensus processes, the authors perform an extensive assessment on blockchain network energy usage and consensus algorithms. The assessment draws attention to the possible environmental advantages of implementing an energy-efficient strategy by contrasting the energy consumption of the suggested framework with that of conventional proof-of-work cryptocurrencies.

Transaction Speed: One of the most important factors in deciding if cryptocurrencies are useful in practical applications is transaction speed. The performance of proof-of-work blockchains with regard to transaction confirmation times is investigated in the work of Gervais et al. (2016). This assessment establishes whether the suggested framework can accomplish quicker transaction processing by contrasting the transaction speed of the suggested energy-efficient framework with that of well-known cryptocurrencies like Ethereum and Bitcoin.

Cost-effectiveness is a crucial factor to consider while assessing the usefulness of the suggested framework. The study conducted by Bonneau et al. (2015) sheds light on the difficulties and economic viewpoints around Bitcoin and other cryptocurrencies, including transaction fees. This assessment evaluates the possible financial benefits of adopting the new framework by comparing transaction fees and cost-effectiveness between the proposed energy-efficient framework and traditional cryptocurrencies.

The assessment of the suggested energy-efficient framework seeks to highlight its potential as a workable and sustainable solution for regular transactions by highlighting its advantages over current cryptocurrencies and other energy-efficient blockchain projects through the analysis of energy consumption, transaction speed, and cost-effectiveness metrics.
The steps taken to guarantee the security and decentralisation of the suggested energy-efficient framework while reducing energy usage are covered in this part. An understanding of the

methods used to create a reliable and secure system is provided by the insights from several research and review publications.

Security Measures: A thorough analysis of the security implications of consensus protocols in blockchain systems is provided by Kiayias et al.'s (2018) research. The notion of proof-of-work that is non-interactive is examined by the writers in order to improve the security of blockchain networks. The part goes into detail on how the suggested architecture makes use of secure consensus processes to fend off any assaults and preserve the integrity of the system by using findings from this study.

Decentralisation Strategies: A blockchain network's overall resilience and ability to withstand censorship depend on its ability to remain decentralised. The study conducted by Garay and colleagues (2019) explores methods for expanding decentralised blockchains while maintaining their decentralised characteristics. These techniques are incorporated into the section to clarify how the suggested architecture guarantees a dispersed network structure, lessening the dependency on a centralised authority, and fostering an ecosystem that is inclusive.

Energy-efficient Security Protocols: Pass and Shi's (2016) study presents energy-efficient security protocols that may be used with blockchain systems in order to achieve a balance between security and energy efficiency. The integration of these protocols by the suggested framework to reduce energy usage and uphold security standards is covered in this section.

This section emphasises the crucial factors and steps taken to guarantee the security and decentralisation of the suggested energy-efficient framework by utilising insights from these research publications. All these initiatives work together to build a reliable and long-lasting framework for regular bitcoin transactions.

User Experience and Usability: This section explores the vital aspects of user experience and usability, which are essential to any cryptocurrency's everyday viability. The user interface, usability, and accessibility of the suggested energy-efficient framework are addressed to improve its usefulness for frequent users by incorporating insights from a range of research and review publications.

User Interface Design: Huang and Leitner's (2017) study highlights the importance of UX design for blockchain applications. Examining aspects such as information display, transaction flow, and user involvement, the study explores the potential and problems associated with creating user-friendly interfaces for blockchain systems. The section describes how the suggested framework optimises its user interface to enhance the overall user experience, incorporating best practices from this study.

Adoption and Usability: Lehr and Uygun's (2020) study examines consumers' opinions and experiences with a range of digital currencies in order to identify the variables influencing these aspects. The results offer important new information about user expectations and difficulties with cryptocurrency use. The section explains how these issues are addressed by the suggested architecture to produce a platform that is easier to use and more accessible.

Accessibility for Non-Technical Users: Reinhardt et al. (2018) investigate the obstacles to non-technical users' adoption of blockchain technology. The article emphasises how cryptocurrencies might be made more understandable for a larger audience by streamlining technical jargon and complicated concepts. This section uses the results of this study to illustrate how the user-friendliness of the proposed energy-efficient framework was prioritised in order to make it usable by non-technical users as well.

The section highlights the value of usability and user experience in augmenting the feasibility of the suggested energy-efficient framework for everyday users by incorporating lessons from various research articles. For regular bitcoin transactions, a more user-friendly and attractive platform is produced by taking accessibility, simplicity of use, and user interface design into mind.

Conclusion

In addition to offering a convincing answer to the problems facing existing cryptocurrencies, the suggested energy-efficient architecture may encourage broader acceptance of cryptocurrencies in day-to-day activities. To further advance the usefulness, sustainability, and practicality of cryptocurrencies for daily transactions, future research areas might look into more security advancements, usability improvements, and optimisations.

The energy-efficient architecture has the potential to make cryptocurrencies a more practical and environmentally responsible choice for daily financial transactions and beyond, as the world continues to adopt digital currencies and blockchain technology.

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