Asia Proceedings of Social Sciences

Journal Homepage: https://readersinsight.net/APSS

9th ASIA International Conference (Langkawi, Malaysia)

Comparison Analysis of Blockchain Consensus Algorithms in Decentralized Public Environment: A Review

Muhammad Anus*,

Faculty of Computing
University of Technology Malaysia, 81310, Skudai, Johor
Malaysia
anasaltaf7177@gmail.com

Asri Bin Ngadi

Faculty of Computing
University of Technology Malaysia, 81310, Skudai, Johor
Malaysia
dr.asri@utm.my

***Corresponding Author email: muhammadanus@graduate.utm.my**

Submitted: 27 February 2024 *Revised: 19 March 2024* *Accepted: 22 March 2024*

Peer-review under responsibility of 9th ASIA International Conference (Langkawi, Malaysia) Scientific Committee
http://connectingasia.org/scientific-committee/
© 2024 Published by Readers Insight Publisher,
Office # 6, First Floor, A & K Plaza, Near D Watson, F-10 Markaz, Islamabad. Pakistan,
editor@readersinsight.net

This is an open access article under the CC BY license (http://creativecommons.org/licenses/4.0/).

https://doi.org/10.31580/jm7sfp03

© 2024 The Authors. Published by Readers Insight Publisher. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/)

ABSTRACT

The rapid evolution of blockchain technology has led to the development of various consensus algorithms (Ben-Sasson et al., 2014), each with distinct characteristics that influence the scalability, decentralization, energy efficiency, and transaction costs within decentralized public environments (Ampel et al., 2019). This study provides a comprehensive review of prominent consensus mechanisms (Block & Marcussen, 2019), including Proof of Work (PoW), Proof of Stake (PoS), Proof of Elapsed Time (PoET), and others, to elucidate their operational principles (Hu et al., 2021), strengths, and limitations (Al-Housni, 2019). Through a systematic comparison based on defined parameters, we dissect the transaction processes across different blockchains to understand their suitability for diverse applications. Our findings reveal significant trade-offs among the chosen algorithms, highlighting how they balance efficiency with security and decentralization. The analysis aims to offer insights into optimizing blockchain design for enhanced performance and sustainability, addressing the critical challenges faced by current and future decentralized systems. This paper not only serves as a guide for selecting appropriate consensus algorithms for specific needs but also sets the stage for further research into developing more robust and efficient blockchain frameworks.

Keywords: *Blockchain; Consensus Algorithms; Decentralization; Energy Efficiency; Transaction Costs; Proof of Work; Proof of Stake; Public Blockchains*

RESEARCH HIGHLIGHTS

Proof of History (PoH) and Delegated Proof of Stake (DPoS) stand out for their high transaction throughput capabilities, with PoH enabling very high transactions per minute due to its unique time-sequencing method, making it ideal for applications requiring rapid processing. DPoS, with its delegate selection process, also supports scalability by streamlining the validation process.

Proof of Stake (PoS) and its variants, including DPoS and Proof of Importance (PoI), are noted for their low energy consumption compared to Proof of Work (PoW). These algorithms eliminate the computationally intensive process of mining, significantly reducing the energy requirements and making them more sustainable options for blockchain networks.

PoS, DPoS, and PoA typically offer lower transaction costs due to their less resource-intensive consensus processes. Lower costs are attributed to the elimination of energy-intensive mining operations, as seen in PoW, facilitating more economical transactions.

GRAPHICAL ABSTRACT

Consensus Algorithm	Approx. Transactions per Minute (TPM)	Estimated Energy Cost per Transaction (kWh)
PoW (Proof of Work)	7 (Bitcoin)	707 (Bitcoin)
PoS (Proof of Stake)	1,000 (Peercoin, early example)	0.01
DPoS (Delegated Proof of Stake)	2,000+ (EOS)	<0.01
PoA (Proof of Authority)	2,000 (VeChain)	Very minimal, not precisely quantified
PoSpace/PoC (Proof of Space/ Capacity)	500 (Chia)	Variable, generally lower than PoW
PoB (Proof of Burn)	100 (Slimcoin, theoretical)	Depends on the currency burned; indirect energy cost
PoET (Proof of Elapsed Time)	2,000+ (Hyperledger Sawtooth)	Minimal, specific figures not widely reported
PoActivity (Proof of Activity)	100-1,000 (Decred)	Moderate, less than PoW but varies
PoI (Proof of Importance)	1,000+ (NEM)	<0.01
PoH (Proof of History)	50,000+ (Solana)	Not explicitly reported, but designed to be low
PoRep (Proof of Replication)	Depends on network usage (Filecoin)	Lower than PoW, specific kWh not reported

Fig. 1. Comparison Results

Research Objectives

The research aims to comprehensively review various consensus algorithms within blockchain technology, such as Proof of Work (PoW), Proof of Stake (PoS), and Proof of Elapsed Time (PoET), to discern their operational mechanisms, strengths, and limitations. By systematically comparing these algorithms across defined parameters like scalability, decentralization, energy efficiency, transaction costs, security, and governance, the study seeks to provide valuable insights into their suitability for diverse applications. Through dissecting transaction processes across different blockchains, the research endeavors to optimize blockchain design for improved performance and sustainability. Additionally, the paper addresses critical challenges faced by decentralized systems, including governance issues, scalability concerns, security risks, and transaction efficiency, offering key recommendations and insights for decision-makers. Serving as a guide for selecting appropriate consensus algorithms and setting the stage for further research, the study contributes to the development of more robust and efficient blockchain frameworks, ultimately facilitating broader adoption and success of blockchain technology in various domains.

Methodology

The methodology involves conducting a comprehensive review of literature on blockchain consensus algorithms, encompassing scholarly articles, research papers, and technical documentation. Initial data collection entails identifying relevant studies addressing various consensus mechanisms and their performance metrics. Subsequently, a systematic comparison is conducted, focusing on parameters such as scalability, decentralization, energy efficiency, transaction costs, security, and governance. This comparative analysis forms the basis for evaluating the strengths and limitations of each algorithm. Additionally, transaction processes across different blockchains are dissected to understand their applicability in diverse scenarios. The methodology also involves qualitative analysis to synthesize findings and draw meaningful conclusions. By employing a rigorous and structured approach, this study aims to provide valuable insights into optimizing blockchain design for enhanced performance and sustainability, thereby addressing critical challenges faced by decentralized systems.

Results

The comparative analysis revealed distinct strengths and trade-offs among consensus algorithms. Proof of History (PoH) and Delegated Proof of Stake (DPoS) emerged as high-throughput solutions, with PoH facilitating very high transactions per minute due to its unique time-sequencing method, while DPoS streamlines validation through delegate selection. Proof of Stake (PoS) and its variants demonstrated lower energy consumption compared to Proof of Work (PoW), making them more sustainable options. Lower transaction costs were observed with PoS, DPoS, and Proof of Authority (PoA), attributed to the elimination of energy-intensive mining operations. While PoW boasts high decentralization, concerns over mining pool centralization were noted. Overall, the findings underscore the importance of selecting consensus algorithms aligned with specific needs, balancing efficiency, security, and decentralization to ensure the success and viability of blockchain networks.

Findings

The comparative analysis revealed distinct strengths and trade-offs among consensus algorithms. Proof of History (PoH) and Delegated Proof of Stake (DPoS) emerged as high-throughput solutions, with PoH facilitating very high transactions per minute due to its unique time-sequencing method, while DPoS streamlines validation through delegate selection. Proof of Stake (PoS) and its variants demonstrated lower energy consumption compared to Proof of Work (PoW), making them more sustainable options. Lower transaction costs were observed with PoS, DPoS, and Proof of Authority (PoA), attributed to the elimination of energy-intensive mining operations. While PoW boasts high decentralization, concerns over mining pool centralization were noted. Overall, the findings underscore the importance of selecting consensus algorithms aligned with specific needs, balancing efficiency, security, and decentralization to ensure the success and viability of blockchain networks.

References

Al-Housni, N. (2019). *an Exploratory Study in Blockchain Technology*. 88. https://www.research.manchester.ac.uk/portal/files/85712237/FULL_TEXT.PDF

Ampel, B., Patton, M., & Chen, H. (2019). Performance modeling of hyperledger sawtooth blockchain. *2019 IEEE International Conference on Intelligence and Security Informatics, ISI 2019*, 59–61. https://doi.org/10.1109/ISI.2019.8823238

Ben-Sasson, E., Chiesa, A., Garman, C., Green, M., Miers, I., Tromer, E., & Virza, M. (2014). Zerocash: Decentralized anonymous payments from bitcoin. *Proceedings - IEEE Symposium on Security and Privacy*, 459–474. https://doi.org/10.1109/SP.2014.36

Block, P. M., & Marcussen, S. K. (2019). *Blockchain Technology and the Implementation in the Supply Chain : Occuring Barriers.*

Hu, Q., Yan, B., Han, Y., & Yu, J. (2021). An Improved Delegated Proof of Stake Consensus Algorithm. *Procedia Computer Science*, *187*, 341–346. https://doi.org/10.1016/j.procs.2021.04.109

Author's Biography

***Muhammad Anus** is a computer science enthusiast specializing in public blockchain consensus algorithms. They have developed a novel algorithm for rapid transactions in decentralized environments. Currently pursuing a master's by Research/Philosophy in Computer Science at UTM Malaysia, their research focuses on optimizing blockchain performance and scalability for real-world applications. Passionate about advancing technology, they aim to contribute to the evolution of blockchain systems through innovative research and development.*

***Asri Bin Ngadi,** Director of Computer Science at UTM Malaysia, holds expertise in blockchain technology and decentralized systems. With a background in computer science, they have contributed significantly to research in optimizing blockchain design for enhanced performance and sustainability. Their work focuses on addressing critical challenges faced by current and future decentralized systems, providing valuable insights for decision-makers and stakeholders. Through comprehensive analysis and recommendations, they strive to advance the field and foster broader adoption of blockchain technology.*