BLOCKCHAIN SCALABILITY AND EFFICIENCY

**STUDENT NAME:** Lakshmi Pravallika Bhupathi

Nishchala Namburi

Sai Srikar Miriyala

Sowmya Reddy Allugari

Yaswanth Kanakala

Udaykiranreddy Devarapally

**STUDENT NUMBER:** S564196

S564199

S567160

S565488

S567546

S567161

**Advisory Panel:** Dr. Mark Chai

**CONTENTS**

Introduction: 3

Objectives: 4

Literature Review: 6

Methodology: 7

Expected Outcomes: 9

Timeline: 10

Budget: 13

Ethical Considerations: 14

Student Requirements: 15

References: 17

# Introduction

Blockchain, the underlying technology powering the Bitcoin cryptocurrency, is a distributed ledger that creates a distributed consensus on a history of transactions. Cryptocurrency transaction verification takes substantially longer than it does for conventional digital payment systems. Despite blockchain’s appealing benefits, one of its main drawbacks is scalability. Designing a solution that delivers a quicker proof of work is one method for increasing scalability or the rate at which transactions are processed. In this paper, we suggest a solution based on parallel mining rather than solo mining to prevent more than two miners from contributing an equal amount of effort to solving a single block. Moreover, we propose the idea of automatically selecting the optimal manager over all miners by using the particle swarm optimization (PSO) algorithm. [1]

This process solves many problems of blockchain scalability and makes the system more scalable by decreasing the waiting time if the manager fails to respond. Additionally, the proposed model includes the process of a reward system and the distribution of work. In this work, we propose the particle swarm optimization proof of work (PSO-POW) model. Three scenarios have been tested including solo mining, parallel mining without using the PSO process, and parallel mining using the PSO process (PSO-POW model) to ensure the power and robustness of the proposed model. This model has been tested using a range of case situations by adjusting the difficulty level and the number of peers. It has been implemented in a test environment that has all the qualities required to perform proof of work for Bitcoin. A comparison between three different scenarios has been constructed against difficulty levels and the number of peers. Local experimental assessments were carried out, and the findings show that the suggested strategy is workable, solves the scalability problems, and enhances the overall performance of the blockchain network.

# Objectives

**Objective 1: Provide an Expandable Blockchain Solution**

An in-depth analysis will be conducted to create a blockchain paradigm where mining in parallel, as opposed to a solo approach, speeds up transaction processing and limits the number of miners who equally contribute to solving a single block to two. Blockchains are tamper evident and tamper resistant digital ledgers implemented in a distributed  
 fashion (i.e., without a central repository) and usually without a central authority (i.e., a bank, company or government).[2]

**Objective 2: Use Particle Swarm Optimization (PSO) to Select the Best Managers**

Reduce waiting times in the event of a manager failure by using the PSO algorithm to automatically choose the best manager among miners, hence resolving scalability concerns. At their basic level, they enable a community of users to record transactions in a shared ledger within that community, such that under normal operation of the blockchain network no transaction can be changed once published.

**Objective 3: Evaluate the PSO-POW Model**

The main contributions of this work include proposing a solution based on parallel mining rather than solo mining to prevent more than two miners from contributing an equal amount of effort to solving a single block. Additionally, we introduce the idea of automatically selecting the optimal manager over all miners using the particle swarm optimization (PSO) algorithm. This approach addresses many blockchain scalability issues and enhances system scalability by reducing waiting time if the manager fails to respond. Furthermore, the proposed model incorporates a reward system and work distribution process. We propose the particle swarm optimization proof of work (PSO-POW) model, which has been tested in three scenarios: solo mining, parallel mining without the PSO process, and parallel mining using the PSO process (PSO-POW model), demonstrating the model's power and robustness. The model has been evaluated across various case situations by adjusting the difficulty level and the number of peers.

**Objective 4: Reward and Work Distribution System**

A common reality in many contemporary work organizations is the inequity that exists in the distribution of available rewards. One often sees little correlation between those who perform well and those who receive the greatest rewards. At the extreme, it is hard to understand how a company could pay its president $10 to $20 million per year (as many large corporations do) while it pays its secretaries and clerks less than $15,000. Each works approximately 40 hours per week, and both are important for organizational performance.[3] Below diagram refers to the key objectives of blockchain. [Figure 1].

Figure 1: Blockchain objectives

# Literature Review

**Summary of Relevant Literature and Previous Research:**

The research proposes a blockchain scaling solution that uses link mining and particle swarm optimization (PSO) technology to increase transactions between networks like Bitcoin. Known as PSO Proof-of-Work (PSO-POW), the aim of this concept is to improve miner control, increase duration and distribute workable items nicely. The model demonstrates better scalability and performance by testing various scenarios, including separate and parallel operations with and without PSO. Buddy's stability and difficulty levels have been validated by local benchmarks [1]. Yu, Mei, Du, and Luo's paper explores the integration of blockchain technology with Internet of Things (IoT) data to solve the problem of making data recovery possible and impossible. In order to increase the data retrieval efficiency of the blockchain system, it offers new solutions based on transactions and smart contracts, as well as indexing tools based on skip lists [2].

**Identification of Gaps or Areas for Further Investigation:**

Although the work of Yu, Mei, Du, and Luo provides good ideas on scalability for blockchain data ingestion and integration with IoT, there are still areas that need further development to go into further print. These include investigating the security and privacy issues of new models, performing cost-effective business analysis of the model, and testing the proposed model in real life. A detailed comparison with existing blockchain scalability methods is still needed to clarify the advantages or limitations. Key points that have yet to be clarified include how these solutions impact overall network performance, including throughput and latency, in various scenarios, and how they fit into various blockchain topologies. Filling these gaps can be improved.[7]

# Methodology

**Research Design:**

This study adopted a research design experiment to evaluate the effectiveness of the Particle Swarm Optimization Proof-of-Work (PSO-POW) model in improving blockchain scalability. This study compares three mining scenarios by creating a control environment that simulates real blockchain conditions: solo mining, parallel mining without PSO technique, and parallel mining using the PSO-POW model. Distinguishing important variables such as operational complexity and number of participants and examining their impact on blockchain performance and scalability.[5]

**Data collection process:**

Data collection involves setting up a simulated blockchain environment capable of producing proof of work, using three mining scenarios (alone, without PSO, and with PSO-POW). Record performance metrics such as block resolution time, network connectivity, and throughput. Additionally, the difficulty of mining was adjusted and miners were modified to measure the scalability and efficiency of the proposed model in various conditions.

**Data Analysis:**

The performance of the three mining scenarios is assessed through the use of both descriptive and inferential statistics in data analysis. Comparative statistics such as ANOVA and t-tests identify significant differences between scenarios while descriptive statistics provide an overview of performance measures. An examination of the correlation between mining performance difficulty level and peer count is done using multiple regression analysis. By comparing response times and failure rates in various scenarios the PSO algorithms efficacy in choosing the best manager is evaluated.[9]

**Tools/Instruments:**

The research makes use of a wide range of equipment and instruments such as mining hardware (CPUs GPUs) for proof of work tasks and customized blockchain simulation software to build the test environment. Software such as SPSS or R is used for statistical analysis and Python libraries are used to implement the PSO algorithm. Tools for performance monitoring record metrics in real time and data visualization programs like Tableau or matplotlib are used to display and evaluate the data.[6]

# Expected Outcomes

**Expected Outcome 1:** It is expected that the study will show how much faster transactions are processed in the blockchain network when mining occurs in parallel instead of alone. The suggested model seeks to increase the blockchains efficiency by capping the number of miners who equally contribute to solving a single block at two.  
**Expected Outcome 2:** In the event of a manager failure it is anticipated that the Particle Swarm Optimization (PSO) algorithm will effectively reduce waiting times. The PSO process should improve the overall scalability and robustness of the blockchain network guaranteeing continuous and effective operation by automatically choosing the best manager among miners.[7]  
**Expected Outcome 3:** It is anticipated that a comparison of solo mining parallel mining without PSO and parallel mining using the PSO-POW model will demonstrate the PSO-POW models superiority when managing more peers and more difficult difficulty levels. The ability of the suggested model to continue operating at a high level under various circumstances will be confirmed by this result.   
**Expected Outcome 4:** The goal of the study is to show that the PSO-POW model achieves a more equitable and effective resource distribution among miners by integrating a work distribution process and reward system. In actual blockchain applications this will demonstrate the models useful advantages.  
**Expected Outcome 5:** The findings of the study are expected to provide significant new insights and strategies in addition to a comprehensive framework for addressing scalability issues with blockchain technology. This could pave the way for further developments and enhancements in distributed ledger technology.[10]

# TIMELINE

Starting with startup and moving through development, the project timeline encompasses multiple phases, culminating in evaluation and review.

**Months 1-3: Project Initialization**

* Make up goals and research questions. This involves achieving and formulating specific questions that our research which aims in scaling and efficiency of Block Chain
* Perform a literature review over the 10 research papers.
* Develop project proposal and secure approvals. This includes detailed research proposal outlining and involve all the need and methods. Also includes obtaining required approvals from ethical committees or supervisors.

**Months 4-6: Detailed Planning and Design**

* Finalize research methodology where we decide and refine the techniques and methods that we use to gather your data.
* Design data collection processes and instruments is the phase where we develop tools and procedures for the effective collection of data.
* Begin recruitment of research team members is the essential task to assemble a team that will assist in carrying out the research effectively and efficiently.

**Months 7-9: Recruitment and Training**

* Recruit participants- This is where all the participants are necessary for the research and ensure they fit the research criteria.
* Train research team on data collection methods- Educating the team is the crucial task when they need to know the proper techniques for collecting and handling data.
* Pilot testing of data collection instruments. Testing data on a small scale to iron out any issues before full deployment.

**Months 10-12: Data Collection**

* Begin primary data collection. Finalise the data set and preprocess the data and start gathering the main body of the data.
* Regular team meetings to assess progress and address issues. Conducting regular meetings to monitor the progress and resolve any arising issues.
* Data storage and initial data cleaning. This phase involves organizing the preliminary data, clean your data to prepare for analysis.

**Months 13-15: Data Analysis and Initial Findings**

* Complete data cleaning. Make sure all the data is neat and clean of bugs and also make the data balanced to start a sincere analysis.
* Conduct detailed data analysis and dive deep into the dataset to find the answers to problem statements.
* Develop initial findings and prepare interim report, this also includes summarizing the report.

**Months 16-18: Development and Testing**

* Develop initial prototypes of new consensus mechanisms.
* Start preliminary data analysis starts by early analysis to identify any patterns and trends.
* Modify data collection strategies as needed based on interim findings.
* Conduct initial tests on scalability and energy efficiency.

**Months 19-21: Report Writing and Peer Review**

* Draft detailed report of findings.
* Circulate interim report for peer review and check with other sources for other statistical reports.
* Incorporate feedback and refine analysis. Use this feedback to make the project even more successful.

**Months 22-24: Final Review and Dissemination**

* Finalize the research report.
* Present presentations and papers for publication.
* Organize closing workshop/conference to share results.
* Submit findings to relevant stakeholders and academic journals.

# Budget

**Materials/Equipment: $15,000**

This might cover computers, specialized equipment, lab supplies, etc.

**Participant Recruitmen**t: **$15000**

Includes advertising and incentives for participant involvement, such as gift cards or payments.

**Data Collection/Analysis Software: $7500**

Licenses for software like SPSS, SAS, MATLAB, or specialized industry-specific tools.

**Other Expenses: $3500**

Could include travel costs for team members to attend conferences or collect data, publication fees, and other miscellaneous costs.

**Total Estimated Budget: $41,000**

This is a fictitious situation; the actual budget may differ significantly based on study, the location, the size of the project, and the current resources.

# Ethical Considerations

**Ethical Approval:** The study project entails developing and evaluating blockchain models in a virtual setting without the need for confidential information or individuals. As a result, it has very few or no ethical considerations. To guarantee that all data established during the experiment is safely maintained and used for this investigation, the study will adhere to ethical guidelines on data processing.[8]

**Participant Welfare:** Because the research did not involve human participants, no direct concern for participants' health was valid. However, strict rules will be followed when writing and reporting the results of the study. Any use of included external resources, software or hardware will be deemed appropriate and used in accordance with applicable license agreements and intellectual property laws. This approach ensures integrity and ethics as a research project.

# Student Requirements:

**Roles and Responsibilities:**

**Tasks:**

**Literature Review:**

**Sai Srikar Miriyala and Uday Kiran Reddy Devarapally** conducted comprehensive literature searches on blockchain technology, with a particular focus on scalability issues and optimization techniques. She reviewed a variety of academic papers, journals, and conference proceedings related to blockchain, mining strategies, and the PSO algorithm. Through her diligent research, Sai Srikar Miriyala and Uday Kiran Reddy Devarapally summarized key findings and identified gaps in existing research that the proposed PSO-POW model aims to address.

**Data Collection:**

**Yashwanth Kanakala and Nishchala Namburi** assisted in designing the data collection methods, including simulation setups and performance metrics relevant to blockchain mining. They conducted experiments and collected data on the performance of different mining strategies, such as solo mining, parallel mining without PSO, and parallel mining with PSO. Throughout this process Yashwanth Kanakala and Nishchala Namburi ensured data integrity and adherence to experimental protocols. They meticulously organized the collected data for subsequent analysis.

**Data Analysis:**

**Laxmi pravalika Bhupathi** collaborated on analyzing the collected data using both qualitative and quantitative methods. He identified patterns, trends, and insights related to the performance and scalability of the proposed PSO-POW model. Leveraging software tools like Tableau and Power BI, Laxmi pravalika Bhupathi effectively visualized and interpreted the data, providing crucial insights that informed the project's findings and conclusions.

**Reporting:**

**Sowmya Reddy Allugari** contributed to drafting sections of the research report, including the introduction, literature review, methodology, and findings. He played a key role in organizing the research findings into a coherent and structured report. Additionally, Sowmya Reddy Allugari prepared visual aids, charts, and graphs using visualization tools like Power BI, ensuring that the data and findings were presented effectively and comprehensively.

# References

1. Saqib NA, AL-Talla ST. Scaling Up Security and Efficiency in Financial Transactions and Blockchain Systems. Journal of Sensor and Actuator Networks. 2023; 12(2):31. https://doi.org/10.3390/jsan12020031

2. Yu C, Mei N, Du C, Luo H. Blockchain Data Scalability and Retrieval Scheme Based on On-Chain Storage Medium for Internet of Things Data. Electronics. 2023; 12(6):1454. https://doi.org/10.3390/electronics12061454

3. Peram, S.R., Bulla, P. (2020). Blockchains: Improve the scalability and efficiency of conventional blockchain by providing a lightweight block mining and communication algorithm. Ingénierie des Systèmes d’Information, Vol. 25, No. 6, pp. 737-745. https://doi.org/10.18280/isi.250604

4. Shahbandi, M. (2021). Financial Technologies for Accepting Transactions Using Block Chain Technology and Crypto Currency in Digital Marketing. In International Business &amp; Economics Studies (Vol. 3, Issue 4, p. p23). Scholink Co, Ltd. https://doi.org/10.22158/ibes.v3n4p23

5. Xue, H., Chen, D., Zhang, N., Dai, H. N., & Yu, K. (2023). Integration of blockchain and edge computing in internet of things: A survey. Future Generation Computer Systems, 144, 307-326.

6. Kontorovich, K. (2024). The Graphene Application for the Reconfigurable Intelligent Surface (Ris) for the NomaRis-Mimo System Design. Phenomenological View. Eng OA, 2(1), 01-08.

7. Ullah, A. & Imran, S. (2022). Pitfalls and Challenges of Blockchain in Supply Chain and Logistics. In S. Khan (Ed.), Integrating Blockchain Technology Into the Circular Economy (pp. 108-125). IGI Global. <https://doi.org/10.4018/978-1-7998-7642-7.ch007>

8. Akrasi-Mensah NK, Tchao ET, Sikora A, Agbemenu AS, Nunoo-Mensah H, Ahmed A-R, Welte D, Keelson E. An Overview of Technologies for Improving Storage Efficiency in Blockchain-Based IIoT Applications. Electronics. 2022; 11(16):2513. https://doi.org/10.3390/electronics11162513

9. Harshvardhan & Teoh, S. Y. (2022). Improving Shipping Efficiency Industry-Led Consortium Blockchain Smart Contact. Journal of Global Information Management (JGIM), 30(1), 1-32. <http://doi.org/10.4018/JGIM.313035>

10. Vladimír Klapita, Implementation of Electronic Data Interchange as a Method of Communication Between Customers and Transport Company,Transportation Research Procedia, Volume 53, 2021, Pages 174-179, ISSN 2352-1465, https://doi.org/10.1016/j.trpro.2021.02.023.