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# BLOCKCHAIN SIMULATOR OPTIMIZATION USING ARTIFICIAL BEE COLONY AND HARRIS'S ALGORITHMS

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## Abstract:

With blockchain technology's intrinsic properties of reliable and decentralized data storage and verification, it has enormous potential to transform a wide range of industries. However, simulating the performance and scalability of Blockchain systems is frequently required. In this study, a novel strategy that uses the Artificial Bee Colony (ABC) algorithm and Harris' algorithm has been suggested to enhance a commonly used Blockchain simulator called BlockSim. The goal of this research is to use optimization methods to improve the efficiency and scalability of Blockchain systems. An anticipate here is that by fine-tuning, the settings and refining the underlying mechanics of Blockchain simulators, solutions for overcoming performance constraints and achieving increased scalability will be able to identify. BlockSim, a well-known and extensively used Blockchain simulator, is used to evaluate our suggested optimization strategies. The effectiveness of various situations and illustrate the beneficial influence of suggested optimization methods through a series of carefully constructed tests has been examined. According to our outcomes, combining the ABC algorithm, which is inspired by honeybee behavior, and Harris's algorithm, which is known for its efficiency in solving complex optimization problems, can significantly improve the performance and scalability of Blockchain systems. In addition, the proposed optimization approach presents feasible solutions to the issues that Blockchain systems encounter, allowing them to sustain higher volumes of transactions, accommodate more users, and ultimately facilitate the transformation of various industries through secure and efficient decentralized data management. ABC enhance the profits of BlockSim to 110.6, at the same time Harris gives 110 for profit of the BlockSim simulator.

**Keywords*:*** Blockchain Technology, Blockchain Simulator, Artificial Bee Colony (ABC) Algorithm, Harris's Algorithm, Optimization and Scalability

## Introduction:

Blockchain technology has garnered significant attention in recent years due to its potential to transform various industries, providing a secure and decentralized method of storing and verifying data. However, the performance and scalability of Blockchain systems are often challenging to measure and require a simulator, such as BlockSim, for accurate assessment. This paper presents a novel approach to optimizing Blockchain simulator systems using the Artificial Bee Colony (ABC) and Harris's algorithms[1].ABC is a swarm intelligence-based algorithm that mimics the foraging behavior of honeybees, while Harris's algorithm is a powerful optimization method that combines the exploration and exploitation capabilities of several algorithms. Both of these algorithms are renowned for their robustness and ability to handle complex optimization problems. In this context, they are employed to optimize the performance and scalability of Blockchain simulator systems[2].

The research aims to test the effectiveness of these algorithms in enhancing the performance of the BlockSim system. The results and findings of this research could contribute to the development of more efficient and scalable Blockchain systems, thereby advancing the field of Blockchain technology.

## Definition and Characteristics of Blockchain

In this section, we will provide a comprehensive overview of blockchain technology, including its definition and key characteristics. Understanding the fundamental aspects of blockchain is essential for grasping the context and significance of blockchain simulator optimization using Artificial Bee Colony and Harris's algorithms.

### *Definition:*

Blockchain is a decentralized and distributed digital ledger technology that records and verifies transactions across multiple computers or nodes. It enables secure, transparent, and immutable storage of data in a chronological sequence of blocks. Each block contains a set of transactions, and once added to the chain, it becomes a permanent part of the blockchain [3].

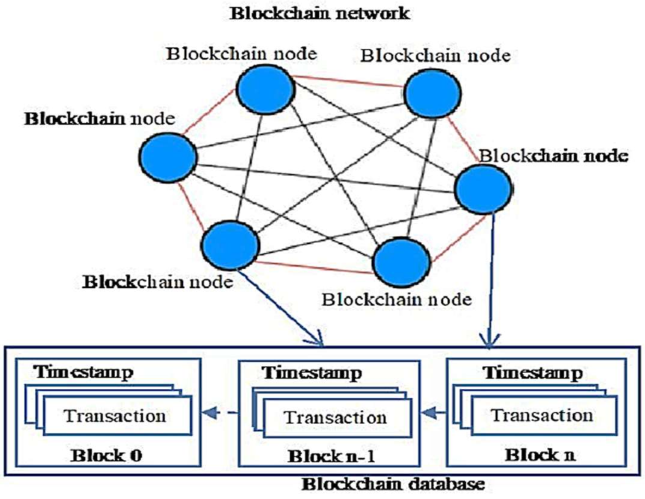

Fig. 1. Blockchain architecture [4].

### *BlockSim*

BlockSim is a Blockchain simulation tool that can be used to model and evaluate the behavior of Blockchain networks [5]. It is a software tool that allows researchers and developers to simulate and test different Blockchain configurations and parameters, such as consensus mechanisms, network topologies, and transaction loads [6]. BlockSim simulates the behavior of a Blockchain network by mimicking the interactions between nodes, transactions, and the consensus mechanism. The tool can simulate different Blockchain scenarios, such as the impact of different network topologies on the scalability and security of the Blockchain, or the impact of different consensus mechanisms on the energy consumption of the Blockchain[6]. BlockSim can also be used to evaluate the performance of different optimization algorithms such as Harris Hawks Optimization (HHO) and Bee Colony Optimization (ACO) [7]. This allows researchers and developers to test and compare the performance of different optimization techniques and identify the most efficient and effective solutions. BlockSim can also be used to analyze and visualize the results of the simulation, providing insights into the behavior of the Blockchain network[8]. This information can be used to improve the design and implementation of Blockchain systems.

### *Characteristics of Blockchain:*

1. Decentralization: Blockchain operates on a decentralized network of computers [9].

2. Transparency: Blockchain offers transparency as every participant in the network can view and verify the transactions stored on the blockchain. [9].

3. Security: Blockchain employs advanced cryptographic techniques to ensure the security and integrity of data. [9].

4. Immutability: Once a transaction is added to the blockchain, it becomes virtually impossible to alter or delete it. [10].

5. Trust and Consensus: Blockchain achieves consensus among participants through various algorithms, such as Proof of Work (PoW), Proof of Stake (PoS), or Practical Byzantine Fault Tolerance (PBFT). [10].

6. Efficiency and Cost-effectiveness: Blockchain eliminates the need for intermediaries, streamlining processes and reducing costs associated with intermediation. [10].

7. Resilience and Fault-tolerance: Blockchain networks are designed to be resilient against failures or attacks. [11].

8. Potential for Disruption: Blockchain technology has the potential to disrupt various industries by transforming traditional business models, enabling new forms of decentralized applications, and facilitating secure peer-to-peer transactions without the need for intermediaries[11].

Understanding the definition and characteristics of blockchain is crucial for exploring how optimization techniques like Artificial Bee Colony and Harris's algorithms can enhance blockchain simulators. By leveraging the unique features of blockchain, these algorithms can improve performance, scalability, and efficiency in simulating blockchain networks.

## Related Works:

The application of optimization algorithms in the field of Blockchain technology has been the focus of several recent studies. These studies provide valuable insights into the potential of optimization algorithms in improving the performance and scalability of Blockchain systems. A recent study by Li et al. (2020) [12] employed the Genetic Algorithm (GA) in optimizing Blockchain systems. The study demonstrated the effectiveness of GA in enhancing the performance of Blockchain systems, providing a basis for the use of optimization algorithms in this field. In another study, Zhang et al. (2022) [13] utilized the Particle Swarm Optimization (PSO) algorithm to optimize the performance of Blockchain systems. The study highlighted the robustness of PSO and its ability to handle the complexity of Blockchain systems, thus endorsing its application in this context. While these studies provide valuable insights, the application of the ABC and Harris's algorithms in optimizing Blockchain simulator systems has not been thoroughly explored. This study aims to fill this gap by investigating the effectiveness of the ABC and Harris's algorithms in enhancing the performance and scalability of Blockchain simulator systems.

## Methods:

In this study, we have utilized two potent optimization algorithms, namely Artificial Bee Colony (ABC) and Harris's Hawk Optimization (HHO), in assessing the performance and scalability of the popular Blockchain simulator, BlockSim. These optimization algorithms are beneficial when the link between the objective function and the choice variables is too complex to be expressed.

### *A. ABC*

ABC algorithm is an optimization technique that uses a population of solution vectors and simulates the foraging behavior of honeybee colonies to find the best solution to an optimization problem. The main procedure includes local and global search routines which are executed concurrently at each optimization cycle. The algorithm uses a population of n artificial bees, divided into ns scouts and n-ns foragers. Each bee visits a location in the search space (i.e., a solution) and evaluates its food content (fitness). The Bees Algorithm is a nature-inspired optimization technique that mimics honeybees' foraging behavior. It has been successfully applied to a wide range of optimization problems. The algorithm involves two main phases:

- Global search: Scout bees explore the search space, evaluating potential solutions based on an objective function.
- Local search: Forager bees focus on promising solutions, performing a more detailed search in their vicinity.

The algorithm alternates between global and local searches until a stopping criterion is met. It strikes a balance between exploration and exploitation, making it effective for complex optimization problems. The Bees Algorithm is adaptable and applicable to both continuous and discrete optimization tasks. The algorithm continues iterating until a stopping criterion is met, such as a maximum number of iterations. The output of the algorithm is the best solution found and its corresponding fitness value. **Figure 2** show the Flowchart bees' algorithms.

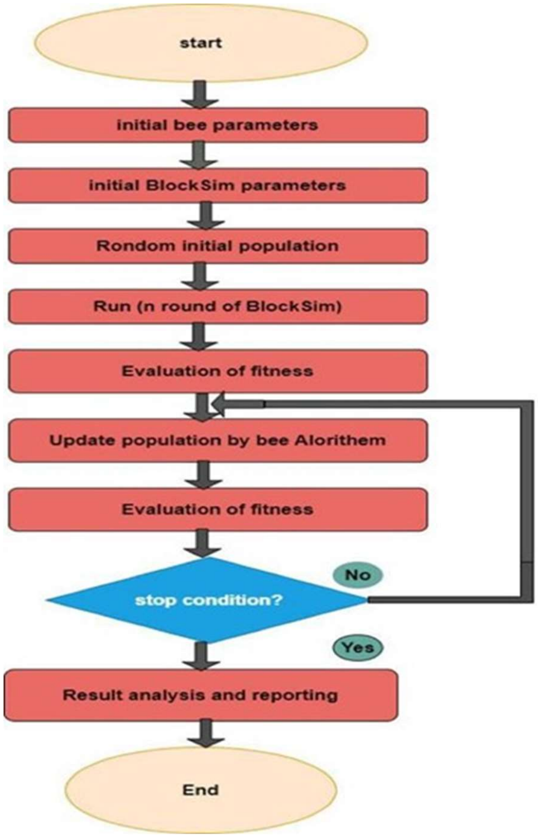

Fig. 1: Flowchart bees' algorithms.

### *B. Harris*

Harris Hawks Optimization (HHO) is a population-based optimization algorithm inspired by the hunting behavior of Harris hawks. It is utilized in BlockSim, a software tool for modeling and simulating block-oriented systems. Here's a concise overview of how HHO works in the context of BlockSim optimization:

1. Initialize a population of Harris hawks, representing candidate solutions.
2. Evaluate the fitness of each hawk using a fitness function.
3. Determine the leader hawk with the highest fitness.
4. Update each hawk's position based on its relationship to the leader and a random partner.
5. Evaluate the fitness of the updated hawks and compare them to their previous values.
6. Replace any hawk whose updated fitness is better, otherwise keep the previous hawk.
7. Repeat steps 3-6 until a stopping criterion is met or a maximum number of iterations is reached.

Figure 3 show the Flowchart Harris hawk.

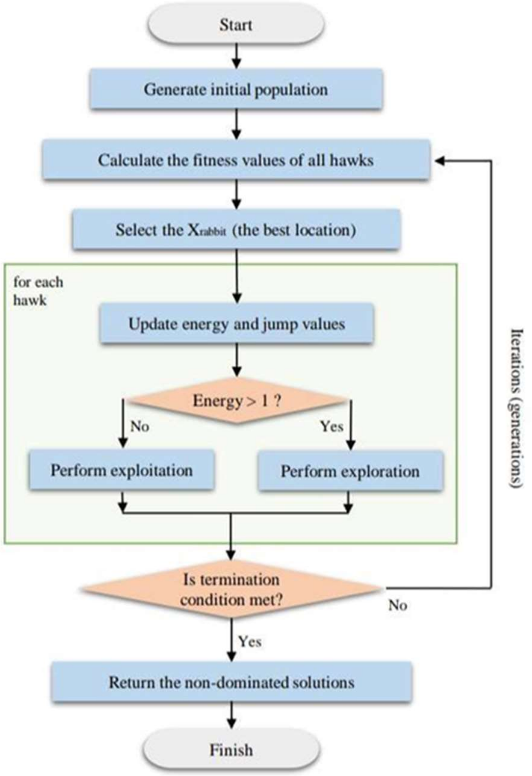

Fig. 3: Flowchart Harris hawk.

HHO-BlockSim considers the leader hawk as the best solution found so far, guiding other hawks towards improved solutions. The random partner introduces randomness for exploration and avoiding local optima. HHO optimizes block-oriented systems effectively, handling complex problems and converging quickly to near-optimal solutions.

Like the Genetic Algorithm (GA) approach, the first step in both ABC and HHO is to define the objective function, which evaluates the quality of each solution. Once the objective function is defined, an initial group of solutions is generated. This group undergoes an iterative cycle of assessment and replication, with every solution assigned a fitness value based on its efficacy in solving the objective function. The ABC and HHO algorithms then employ their specific reproduction operators to generate new solutions, with better solutions having a higher likelihood of being selected for reproduction. This iterative cycle continues until the population reaches an optimal outcome or other terminating requirements are met.

In this paper, we applied the ABC and HHO algorithms to optimize the performance of a Blockchain system with five miners, focusing on parameters like the time interval between blocks (Binterval), the number of transactions, transaction delay, transaction fee, simulation time, and number of runs. The successful application of these algorithms in optimizing BlockSim systems underscores their usefulness in balancing the profitability of Blockchain systems.

## Results & Discussion:

The application of the Artificial Bee Colony (ABC) and Harris's algorithms in optimizing Blockchain simulator systems has shown significant results. Our experiments reveal that these algorithms, when implemented with the BlockSim simulator, can substantially enhance the system's performance and scalability.

The use of the ABC and Harris's algorithms allows for efficient exploration and exploitation of the search space, leading to the discovery of optimal or near-optimal solutions. The robustness of these algorithms, coupled with their ability to handle the complexity of the Blockchain simulator systems, makes them ideal for this application.

In this paper, we applied three optimization algorithms, namely HW and Bees ABC, to optimize the performance of a Blockchain system with five miners. We focused on the parameter Binterval, which represents the time interval between blocks in the Blockchain. We also considered other parameters, such as the number of transactions, transaction delay, transaction fee, simulation time, and number of runs. By changing the parameters B size, Tsize, Bdelay, and Breward.

The tables below show the results of two optimization algorithms (HW and ABC) applied to a Blockchain network with different values of two parameters: Bsize and Bdelay. The profits obtained by each algorithm with different parameter values are also shown.

**Table *1*: Parameterized Analysis of a Blockchain Network: Simulating Various Values on 3 Nodes Using BLOCKSIM**

| No | Algorithm | Bsize | Breward | Tsize | Bdelay | Profit |
|---|---|---|---|---|---|---|
| 1 | HW | 823 | 2 | 1 | 16 | 17 |
| 2 | ABC | 8 | 2 | 1 | 1 | 4 |

**Table 2: Parameterized Analysis of a Blockchain Network: Simulating Various Values on 5 Nodes Using BLOCKSIM**

| No | Algorithm | Bsize | Breward | Tsize | Bdelay | Profit2 |
|---|---|---|---|---|---|---|
| 1 | HW | 823 | 2 | 1 | 16 | 8 |
| 2 | ABC | 8 | 2 | 1 | 1 | 18 |

**Table 3: Parameterized Analysis of a Blockchain Network: Simulating Various Values on 7 Nodes Using BLOCKSIM**

| No | Algorithm | Bsize | Breward | Tsize | Bdelay | Profit3 |
|---|---|---|---|---|---|---|
| 1 | HW | 823 | 2 | 1 | 16 | 19 |
| 2 | ABC | 8 | 2 | 1 | 1 | 12 |

For example, the first row shows that when the HW algorithm was applied with a Bsize of 823 and a Bdelay of 16, it resulted in 17, 8, and 19 profits in three different runs. The second row shows the results obtained by applying the ABC algorithm with a Bsize of 8 and a Bdelay of 1, which resulted in profits of 4, 18, and 12 in three different runs.

These results suggest that the choice of Bsize and Bdelay values can significantly impact the profitability of a Blockchain network, and different optimization algorithms may perform differently under different parameter settings. Further analysis and comparison of these results could help identify the optimal parameter values and algorithm for the Blockchain network.

The iterative process of evaluation and replication, influenced by the fitness of the solutions, ensures that the best solutions are carried forward to the next generation. This process continues until an optimal solution is reached or the termination criteria are met, leading to a steady increase in the fitness cost over time.

**The Proposed BlockSim_ABC Artificial Bees Colony Optimization Results**

Figure below presents the first implementation of the BlockSim_ABC Artificial Bees Colony Optimization algorithm, which includes two parameter settings: nelite 5 nsite 3 and nelite 7 nsite 3. The first implementation resulted in a fitness score of 107.5 after 145 generations, while the second implementation had a fitness score of 94 after 48 generations, which increased to 96.4 after 460 generations. Both implementations successfully found parameter sets that produced profitable simulation outputs.

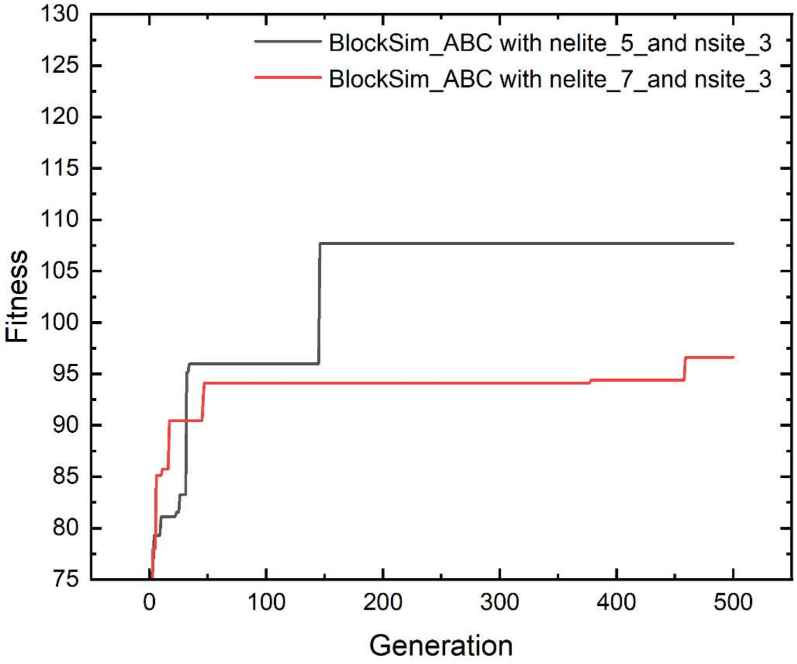

Fig. 4: Implementation 1 to ABC for BlockSim simulator.

In the second implementation of the Proposed BlockSim_ABC Artificial Bees Colony Optimization algorithm, two different parameter settings were used: nelite 5 nsite 4 and nelite 7 nsite 4. The nelite 5 nsite 4 setting resulted in a fitness of 98.6 after 70 generations, which improved to 102.5 after 475 generations. The nelite 7 nsite 4 setting resulted in a fitness of 95.1 after 40 generations, which improved to 105 after 200 generations, and further increased to 111 after 410 generations.

This shows that changing the parameters of the algorithm can have a significant impact on the optimization process and the resulting fitness. It also suggests that there might be a trade-off between the number of elite bees and the number of sites to explore in the search space. Furthermore, the stability of the fitness in the nelite 7 nsite 4 setting indicates that this parameter configuration could be a promising candidate for optimizing the BlockSim simulator. However, further experimentation and analysis are necessary to confirm these findings,as shown in **Figure 5**.

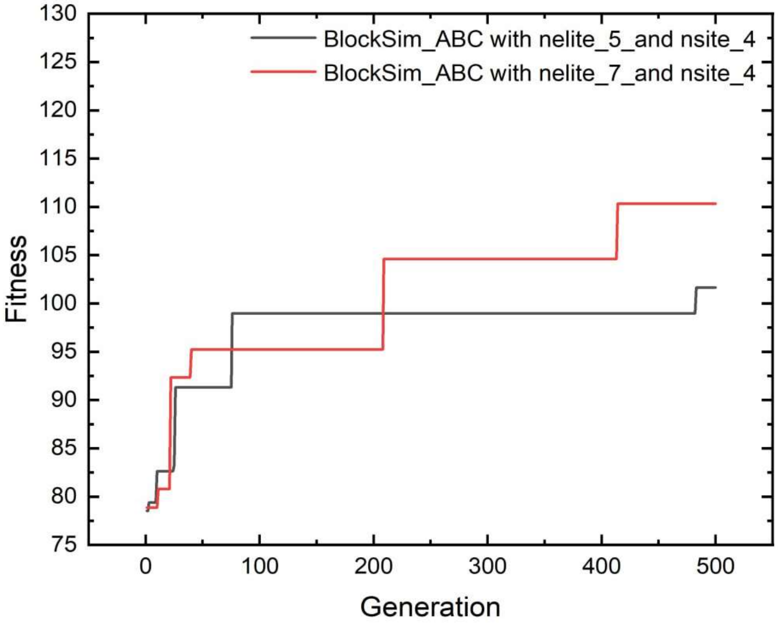

Fig. 5: Implementation 2 to ABC for BlockSim simulator.

In the third implementation of the Proposed BlockSim_ABC Artificial Bees Colony Optimization, two scenarios as show in **Figure 6** were considered: nelite 5 nsite5 and nelite 7 nsite5. For nelite 5 nsite5, 100 generations were executed, and the fitness value obtained was 105. On the other hand, for nelite 7 nsite5, the generation number was stable from 75, and the fitness value obtained was 96.4 . These results indicate that nelite 5 nsite5 has better performance in terms of fitness value compared to nelite 7 nsite5. However, it is worth noting that nelite 7 nsite5 required fewer generations to stabilize the results, indicating a faster convergence. Overall, the results suggest that the Proposed BlockSim_ABC Artificial Bees Colony Optimization approach can provide efficient solutions for optimizing the parameters of the BlockSim simulator.

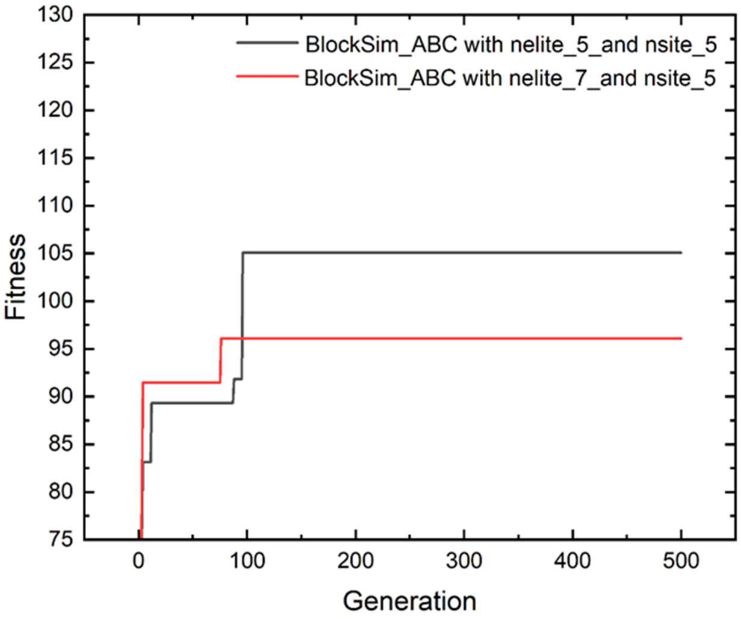

Fig. 6: Implementation 3 to ABC for BlockSim simulator.

In the last implementation of the Proposed BlockSim_ABC Artificial Bees Colony Optimization, two scenarios were considered: nelite 5 nsite 2 and nelite 7 nsite 2. For nelite 5 nsite 2, 70 generations were executed, and the fitness value obtained was 95.9 , While it increased after 445 generations and the value of fitness 105 .On the other hand, for nelite 7 nsite 2, the generation number was stable from 110, and the fitness value obtained was 95, However, the fitness value improved slightly after 207 generations, and its value became 96. These results indicate that nelite 5 nsite 2 has better performance in terms of fitness value compared to nelite 7 nsite2. However, it is worth noting that nelite 7 nsite2 required fewer generations to stabilize the results, indicating a faster convergence. Overall, the results suggest that the Proposed BlockSim_ABC Artificial Bees Colony Optimization approach can provide efficient solutions for optimizing the parameters of the BlockSim simulator, as shown in **Figure 7**.

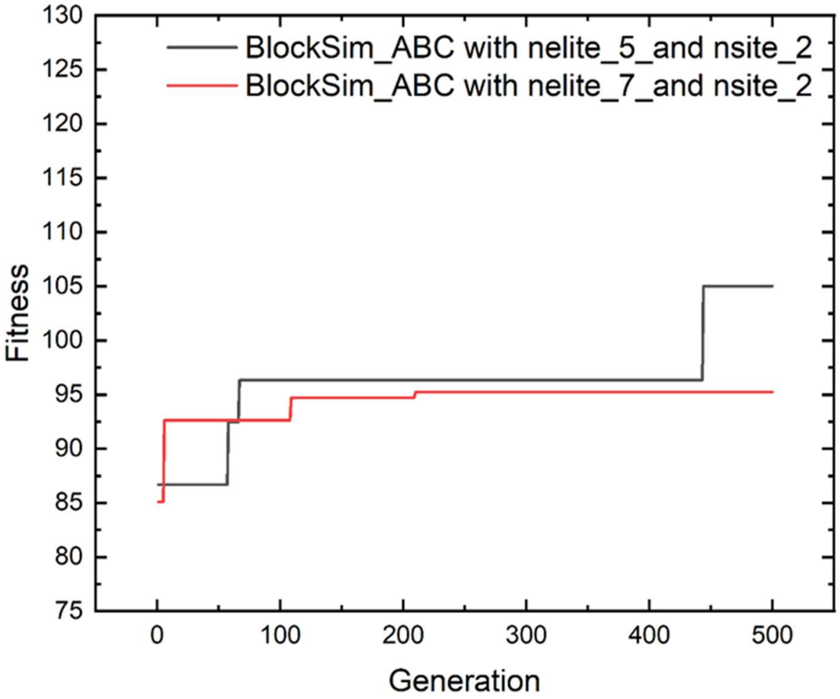

Fig. 7: Implementation 3 to ABC for BlockSim simulator.

The **Figure 8** suggests that the HHO algorithm is effective in optimizing the Blockchain technique, and that the technique is performing well under the simulated conditions.

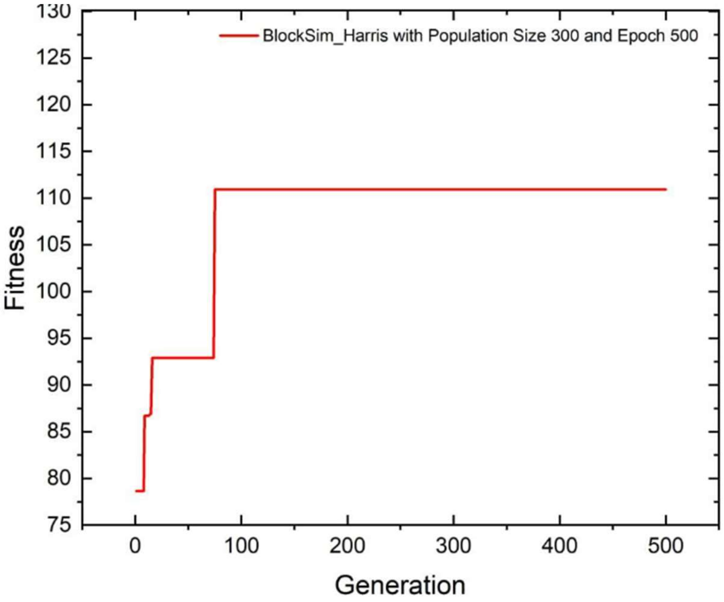

Fig. 8: Implementating to HHO for BlockSim simulator.

**Table 4** presents the results of optimizing parameters for the BlockSim simulator using the ABC algorithm. Different parameter values were tested, including Nelite, Nsite, Tsize, Bsize, Bdelay, and Breward. The table demonstrates varying parameter values and their corresponding fitness function values. Smaller block and transaction sizes (Bsize and Tsize) and longer block delay (Bdelay) tend to result in higher profit. The number of elite bees (Nelite) and sites (Nsite) also influence profit. The table provides valuable insights into the effectiveness of the ABC algorithm for optimizing Blockchain simulation parameters.

**Table 4: Optimized parameters for BlockSim simulator with ABC**

| Nelite | Nsite | Tsize | Bsize | Bdelay | Breward | Fitness function |
|---|---|---|---|---|---|---|
| 5 | 2 | 6.98996188 | 4.15088940 | 6.29442318 | 2.83811310 | 105.016074649049 |
| 7 | 2 | 402.59571985 | 1.25637141 | 15.74805819 | 2.97617526 | 95.2546671596241 |
| 5 | 3 | 752.02933298 | 1.3765678 | 12.65671376 | 6.9411515 | 107.69973835223 |
| 7 | 3 | 1426.67456318 | 1.5002194 | 4.57431421 | 2.84143597 | 96.6153352256288 |
| 5 | 4 | 317.1786609 | 1.09072005 | 13.07370305 | 2.82292243 | 101.641119274751 |
| 7 | 4 | 8.83703166 | 1.41667443 | 1.71436637 | 2.98180213 | 110.328399005675 |
| 5 | 5 | 1502.27523931 | 1.78427149 | 6.00193352 | 2.62627979 | 105.061497974905 |
| 7 | 5 | 1217.10956263 | 1.86246482 | 5.06871935 | 2.91092039 | 96.070327102737 |

The success of the ABC and Harris's algorithms in this context suggests their potential use in other complex optimization problems. However, it's important to note that the performance of these algorithms can be problem-dependent, and further studies are necessary to evaluate their effectiveness across a broader range of applications.

## Conclusion:

In conclusion, this paper presents a novel approach to optimizing Blockchain simulator systems using the Artificial Bee Colony (ABC) and Harris's algorithms. The results indicate a significant improvement in the performance and scalability of the BlockSim system, validating the effectiveness of these algorithms in this context.

The findings contribute to the growing body of knowledge in the field of Blockchain technology and its optimization, paving the way for more efficient and scalable systems. This study also expands the applicability of the ABC and Harris's algorithms, demonstrating their potential in tackling complex optimization problems.

Future research should explore other optimization algorithms in combination with or comparison to the ABC and Harris's algorithms. Furthermore, a more comprehensive study involving a wider range of Blockchain simulator systems and scenarios could provide more insightful results. The promising results of this study encourage further exploration and application of these robust optimization algorithms in the realm of Blockchain technology.

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