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Research Article

Hyperledger Fabric Framework For Blockchain Technology Using Tabu Search And Teaching Learning-Based Optimization Algorithm

SANJITH NARAYANAN[1], M. NITHYA[2], SREEJU SREEDHARAN[3]
[1]Department of Computer Science & Engineering, V.M.K.V. Engineering College, Salem, Tamilnadu, India, Email: sanjithnarayanan@hotmail.com; sanjithnarayanan@gmail.com,
[2]Vice Principal & HOD Department of Computer Science and Engineering, V.M.K.V. Engineering College, Salem, Tamilnadu, India, Email: nithya.ph.d@gmail.com
[3]Department of Arts & Science, V.M.K.V. Engineering College, Salem, Tamilnadu, India,
Email: seeju@gmail.com
***Corresponding author**
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ABSTRACT
There has been a steady growth in popularity of the permissioned blockchain platforms recently, among which the Hyperledger Fabric has been identified as one of the most popular distributed ledger platforms. The fabric includes several components like endorsers, committers, and ordering services. Furthermore, it includes different phases of processing in a transaction like the phase of endorsement, commit phase, validation, and ordering phase. Owing to a large number of components or phases, the Fabric will provide different configurable parameters like the block size, channels, state database, and endorsement policies. Therefore, a major challenge while setting up new and effective blockchain networks is identifying the right value set for the parameters. The Tabu Search (TS) with the Teaching Learning Based Optimization (TLBO) is employed for optimizing a block size with an endorsement policy for various channels in this work. The results of the experiment proved that the results of the experiments had better latency and throughput, thus resulting in better and optimum performance.

Keywords: Block Chain Technology, Fabric, Supply Chain, Tabu Search (TS), and Teaching Learning Based Optimization (TLBO).

1. INTRODUCTION

Cryptocurrency refers to a catchphrase in industry and academia. Today, Bitcoin has been enjoying a large amount of success in the capital market, and this was by reaching 10 billion dollars in the year 2016. Using a new form of data storage structure specially designed for this, all Bitcoin network transactions are conducted without the involvement of any third party. The Blockchain is now regarded as a new public ledger with committed transactions in a new list of blocks. The chain expands to be appended to it in a continuous manner. Asymmetric cryptography along with distributed consensus algorithms is applied for ledger consistency and user security. The key traits Blockchain technology issuitability, anonymity, and, finally, persistency; due to which, the blockchain saves in cost and also improve efficiency [1].

Blockchain technology has a form of an underlying mechanism used for cryptocurrencies like Bitcoin. This was introduced in the year 2009 and peaked with a record valuation in the year 2017, thus creating hype in the field of digital currency. Ever since Bitcoin was introduced, other cryptocurrencies have been launched in the market. The blockchain is a "distributed ledger or database" wherein transactions have been documented with regard to the parties that were participating. This includes a chronological chain containing blocks in which every block is taken to be a page in the ledger. This chain continues to grow and keeps discovering newer blocks to includeinto current Blockchain. The transactions will be broadcast through cryptographic communication within the network, and new blocks are created by the miners who verify new transactions as "proof-of-work". The miners further compete with one another to create these blocks. As soon as the winning block gets appended to a certain Blockchain, a public ledger is created after a copy of the block is broadcasted in the network. The miners are accountable for the verification of these transactions and updating the Blockchain [2].

In most cases, in the square, there is a piece of information made on the hash of the past square, timestamp, hash of the current square, and certain other data. Contingent on the administration which is in the square chain applicate, for example, the exchange records, contract records, IoT information record, along with bank clearing records were included. During the time when the exchange has been executed, it will be a hash and will later communicate to every hub. A Merkle tree root is used at the square of every hub to handle large number of records. The last hash and its worth is a new record in a square header, and this was by employing a Merkle tree where information transmission and asset processing were reduced. The timestamp was the time of the square produced. For the mark of the square, Nonce esteem with information had been characterized by clients [3].

Blockchain technology enters the world of the supply chain, thus making it the right way for transactions that are safer. It was capable of disrupting the manner in which it was produced, marketed, and consumed. There was a brisk execution of the purchase orders along with easy processing of invoices, thus with a minimal need for payment reconciliation, thereby eliminating loss of goods. The contracts between the parties were made digital and were automated by eliminating the need for such voluminous article work along with its associated errors such as the risk of fraud and delay. There has been a substantial business value that was delivered by means of increasing transparency, thereby bringing down risks and enhancing the efficacy of Supply Chain Management (SCM) by utilizationof blockchain. This resulted in a manipulation-proof database distributing various replicas of the data so that any unofficial party need to change 51% of all instances for forging an entry. Blockchain helps in reduction of production costs and improve customer satisfaction. This will intervene between the producer and the customer and consolidates transportation and warehousing, thus offering services to the managers for reducing the cost of operation [4].

SCM and Logistics referred to the domains in which blockchains were good fits for various reasons. In the lifecycle of the product, all data generated in each step is documented in the form of a transaction that results in the creation of a permanent history of any product. Blockchain technology helps towards recording of each asset as it moves through various supply chain nodes, track official documents (receipts, orders, invoices, payments) and tracking the digital assets (barcodes, serial numbers, licenses certifications,copyrights) in a unified manner using physical assets. Further, the blockchain was able to effectively contribute to the process of delivery, wear-off of products, maintenance, and introduction of other modalities among complex assembly lines. Supply chain and logistics were capable of being improved to a significant extent by means of introducing new blockchain technology. Even a simple application of such blockchain technology will be able to provide great benefits. By the registration of product transfer on a digital ledger, it can be made viable in identifyingrelevant data for the SCM [5].

The Hyperledger Fabric is an enterprise-grade open-source platform upheld by the IBM and Linux Foundation. Unlike in the case of Bitcoin, the Hyperledger Fabric will not include any form of cryptocurrency. A method to authenticate transactions for creating BPFT blocks is used [6].These transactions were further controlled in the Hyperledger Fabric by using chain code (a smart contract). It allows writing and design applications that could interact with the new network. Based on the official documentation of the Hyperledger Fabric, any other transaction will be a request initiated by the peer to order and validate this. A instantiate request will initialize a new chain code.The peer nodes which include various client applications and ordering nodes form the main components of the Hyperledger Fabric architecture. The order transactions from various applications are collected through the ordering nodes. The fabric includes several components like endorsers, committers, and ordering services. Furthermore, it includes different phases of processing in a transaction like the phase of endorsement, commit phase, validation, and ordering phase. The Fabric has different configurable parameters like the block size, channels, state database, and endorsement policies. Therefore, a major challenge while setting up new and effective blockchain networks is identifying the right value set for the parameters. Thus, to enhance the fabric, the parameters are optimized using metaheuristic algorithms.

The optimization techniques based on metaheuristic algorithms are used in various fields like WSN, neural networks, artificial intelligence, data mining, and distributed network. Tabu Search (TS) refers to the metaheuristic algorithms that were connected to an evolutionary form of computing. These were capable of handling Non-Deterministic

Polynomial (NP)-hard problems that were combinatorial optimization problems. The TS algorithm was also employed to overcome local minima or maxima called local optima. There were several other methods to overcome the problems of local optima. While searching, they were able to provide a major change to local optima [7].

The primary motivation in developing an algorithm based on nature was the capacity of being able to solve various problems of optimization in an efficient and effective manner. There is an assumption that the behaviour and nature were optimum in performance. For the purpose of this work, another optimization method, known as the Teaching–Learning-Based Optimization (TLBO) [8], was proposed to obtain global solutions for the non-linear functions that make use of a lower effort of computation with higher consistency. This method was based on the influence of teachers on the learners in sharing his knowledge with the learner. The quality of the teacher can affect learner performance. It is evident that a good teacher is capable of training learners well to provide better grades. For the purpose of this work, the TLBO and TS methods employed to optimize the parameters in the fabric-based blockchain technology. The remainder of this investigation has been organized in this way. Section 2 explains all the related work in literature. Section 3 discusses the methods employed in this work. Section 4 explains the results of the experiment, and the conclusion was made in Section 5.

2. RELATED WORKS

Shen et al., [9] explored the authenticity of the product to manage copycats where several Brand Name Companies (BNCs) sell their products through their retailers. A new Permissioned Blockchain Technology (PBT) platform is deployed by the BNCs where the PBT was able to combat copycats in a supply chain. Even though the implementation of the PBT can be useful in helping novice customers identify the authenticity of the product with real product quality. The PBT will therefore increase the BNC's profit, social welfare, and customer surplus, thus reducing the profit made by copycats. Furthermore, a conventional form of wisdom shows that the PBT can ensure the supply chain transparency to motivate the firm for producing and further improve the quality of a product. The BNC, however, will reduce product quality while employing the PBP as there can be an improvement to the quality of the product, which may not be profitable in case the customers are able to distinguish between the products that are genuine or imitations. Also, it can extend the same model by taking into consideration the case in which the BNC will implement the PBT. Without employing the effect of double marginalization, even when the novice customers are small in number, blockchain technology can continue to exist.

Govindasamy and Antonidoss [10] presented another novel hybrid optimization algorithm known as the Whale Optimization Algorithm (WOA) integrated for producing the Whale-based Multi-Verse Optimization (W-MVO) algorithm. To secure data for distributors with the blockchain technology in an environment of the cloud, data leakage to other unauthorized users can be avoided. As soon as the cost is brought down, the distributor stores all data in the blockchain using the cloud sector in which every distributor will hold a new hash function for storing data, and this cannot be restored by the other distributors.

Garg et al. [11] had made a measurement of all perceived business benefits of the implementation of this blockchain technology that was used in the banking to establish factors measuringthe benefits. The data had been collected from a total of 291 respondents that were blockchain consultants or marketing experts. Confirmatory Factor Analysis (CFA) was used for assessing both the validity and reliability of this instrument. The results further supported this instrument proposed along with five other forms of constructs. A scale emerging from such work depicted a large degree of uni-dimensionality, validity, along with reliability in these constructs. An instrument will help the decision-makers in measuring the benefits of blockchain. This provided the decision-makers a proper foundational view in terms of measuring the benefits of implementation of the blockchain technology using their current system. Both societal and scientific significance were worked on based on theoretical and practical applications that had been presented.

Sahoo et al., [12] further contributed to logistics management, and to ensure the safe and efficient movement of air cargo, a distributed blockchain layered framework used for both international and national trades was introduced. This was validated mathematically by comparing the cost without implementing the blockchain.

Meidute-Kavaliauskiene et al., [13] had proved the priority of the blood supply hub to cope with all forms of barriers to implementation in the blockchain SCM. Today, blood supply plays a vital role in saving lives,therefore, tracing blood supply is crucial. Another way to ensure SCM of blood supply can be the blockchain system. The presented SCM stream flows receiving blood to patients. There are several other hurdlesto implementing the blockchain. None of these companies tend to design any improvement projects that can resolve barriers owing to the lack of other rare resources. The main constraints faced are obtained from previous studies and with interview experts. The new Delphi methodwas used for customizing the case study. After this, the blood supply hubs get ranked by using the Measurement Alternatives and Ranking According to the Compromise Solution (MARCOS) system. The final analysis shows the unwillingness of the owners to be the highest priority.

Alawi et al., [14] were further applied, and this evaluated the Blockchain technology for the SCM. The approach of research approach included another new Multi-Criteria Decision-Making framework that was based on the Fuzzy Analytical Hierarchy Process. This framework analyzed yet another new set of Blockchain implementation criteria that points out the crucial nature of ranking made in achieving the SCM. Another very crucial criterion was traceability, and this was followed by Security and Smart Contact. Decision-makers were able to employ another new and developed framework in the supply chain for evaluating Blockchain technology, its readiness, and its benefits within the framework of the supply chain. This resulted in an effective allocation of budgets and resources while planning its deployment.

Viriyasitavat and Hoonsopon [15] focused on scrutinizing the technical problems during integration of blockchain into new supply chains that were used in the environment of the industrial Internet of Things. This system architecture had been presented and further prototyped to ensure the Blockchain was available for business process cooperation. Simulation proved the effectiveness observed in enhancingthe robustness, scalability, and adaptability of all business processes to ensure a smart supply chain.

The Hyperledger Fabric was another popular business among the Blockchain platforms. Since it is included in the functionality of executing certain smart contracts, the fabric is now another widely used framework. Even though most of these applications need data throughput that was known earlier, for a developer, it is not easy to choosethe configuration of Fabric network which is able to meet the necessary prospects about performance. Dreyer et al., [16] presented performance analysis for a Hyperledger Fabric v2.0 to focus on throughput evaluation, the rate of error, and latency with its overall scalability. Their results proved that the Fabric v2.0 was able to outperform earlier versions even in the case of an improved smart contract lifecycle.

3. METHODOLOGY

Permissioned blockchains hasidentifiable memberswho are part of blockchain networks that developed for supportingdifferent business applications. The Hyperledger Fabric refers to a new Hyperledger project that was hosted by the Linux Foundation, and this is a distributed ledger that delivered higher confidentiality, flexibility, scalability, and resiliency. In this section, the TS and the TLBO methods were discussed which are used to optimize the block size in the Hyperledger Fabric.

3.1 Database Access

Figure 1 indicates the transaction flow for the Hyperledger Fabric. The flow was grouped into three different phases, which are ordering, endorsement, and commitment. For the purpose of this section, accessing databases has been explained [17].

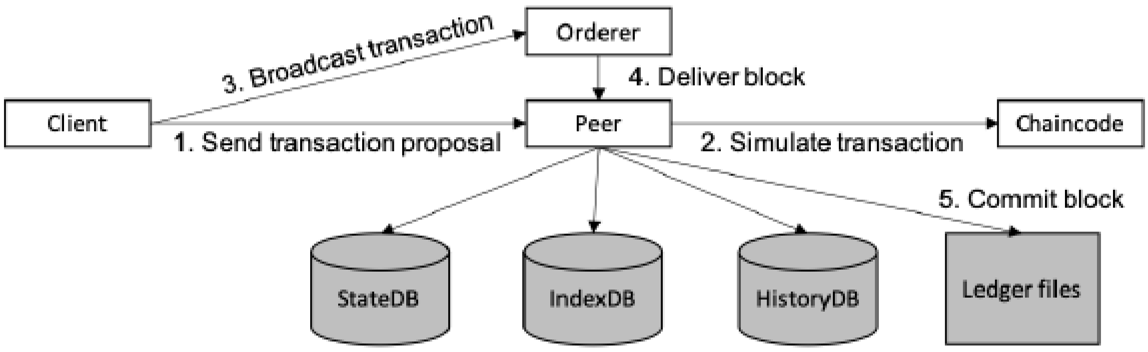

Fig.1: Transaction Flow in Hyperledger Fabric

A. Endorsement Phase

Generally, the customer will initiate a transaction by forwarding a new transaction proposal request to peers. A transaction ID and chaincode ID with several other arguments is mentioned in the request and passed to a chaincode. The transaction read and write sets are simulated by a peer, and this is done by invoking another chaincode to implement this form of business logic. For this, there is a new read set of keys will be accessedfrom the state database (StateDB) into the chaincode with the version numbers connected to this. The write set will denote a set of keys with values that are written using the chaincode. The peer will check if this transaction ID provided has been duplicated using a certain transaction in the ledger during transaction simulation, and this is done by accessing another index database (IndexDB) to store these transaction IDs in the form of keys and the indexes. The check is very important as there was an ID generation algorithm employed in the Hyperledger Fabric may not always ensure the ID and its uniqueness since these are not duplicated. Lastly, the transaction is returned to thecustomer once it is signed using a private key.

B. Ordering Phase

The customer forwards a broadcast request to the orderer on endorsing a transaction that is returned from a peer. An orderer will pack these transactions from the clients to a particular block, andis filed in the ledger files. The block size is regulated based on maximum size, duration and number of transactions. Lastly, the orderersends a block to the peers once it makes use of a private key. It is to be noted that there may not be any database access at this stage.

C. Commit Phase

The peer performs the steps below while receiving a block from the orderer.
1) The Block signatureis validated using a public key that is given by the orderer.
2) The set of signatures from every transaction is validated to meet the endorsement policy.
3) Validate if a version number for each key in the read set is similar to the version number of a key in the StateDB.
4) Write a block to ledger files.
5) Check if the ID for every transaction has been found as unique by means of reading the IndexDB. Once the uniqueness was checked, the four key-value pairs below are written:
_ (a transaction ID, which refers to a pointer to a transaction in ledger files)
_ (an offset for a block refers to a pointer to the transaction in ledger files)
_ (a transaction ID refers to a pointer to the block found in any ledger file)
_ (a transaction ID was the result of a transaction validation)
6) StateDB, update: Here, the values in the write set will be sent to the StateDB, and version numbers for keys linked with values are updated.
7) A change in log for a key to the history database (HistoryDB) is written with a transaction ID and key to a written set.

3.2 Tabu Search (TS) Algorithm

The TS is a meta-heuristic method to be used for solving problems of combinatorial optimization. There has been plenty of attention given to it as it has a flexible framework of control with a great amount of success that could solve NP-hard problems resulting in its rapid growth. It is considered to be different from other techniques of local search as the TS permits movement to another new solution, thus making an objective function worse, hoping it is not trapped in the other local optimal solutions. The TS makes use of a short-term memory called Tabu List (TL) records the search process. Also, it can make use of long-term memories with earlier information on the solutions for improving diversion or intensification of the search [19].

The TS algorithm begins with the initial (current) solution x, known as a configuration, and will calculate the criterion function of the solution. After this, a set of candidate moves neighborhood N (x) for the current solution x are followed. In case the best among these moves is not the TABU, can meet the aspiration criterion, pick the move and take it to be a new current solution. This process is repeated andonce terminated, the best solution until now becomes the solution for the TS as well. It has to be noted that the solution chosen for a particular iteration will be put to the TL to ensure it will not reverse in the successive iterations, wherein the solution is tabu. The 'l' will be the TL and its size. If the length of the TL meets that same size, the first solution will be freed from becoming the TABU, and the new one will enter the same list. This process will continue until such time the TL acts in the form of short-term memory. By making a recording of the history of searches, the TS can control the direction of the search. An aspiration criterion reflects the value for the criterion function. The aspiration criterion will be met, and the TABU restriction will be relieved to move this solution.

3.3 Proposed Teaching-Learning-Based Optimization (TLBO) Algorithm

The TLBO, a population-based algorithm,is modelled on the teaching-learning process in a classroom. This algorithm will simulate two basic methods of learning: by making use of the teacher (the teacher phase) and by interacting with the other learners (the learner phase). In TLBO, a group of learners/studentsrefers to the population and the design variables are represented as different subjects proffered to learners. The results will be analogous to the optimization problem and its fitness value. The best solution will be taken into consideration using the teacher and learner phase [20].

In teacher phase, the algorithm will simulate the learning of all learners using the teacher. The teacher will convey knowledge among learners and aim at bringing about an increase in their mean result for the class. In case for'n' number of learners and 'm' number of subjects. For any other form of sequential teaching-learning cycle, i, $M_{j,\ i}$ will be the mean result for learners in a certain 'j' (j = 1, 2 . . . m). As a teacher can be most knowledgeable on a certain subject, the best learning made in the population will be the teacher for this algorithm. If $X_{total\ -\ kbest,\ i}$ia the result from the best learner keeping all subjects identified as teachers for that cycle, the effort is on the knowledge level of the class. The actual difference between the actual result of the teaching and the mean result of all learners for every subject is depicted in (1):

$$Difference\_Mean_{j,i} = r_i(X_{j,kbest,i} - T_F M_{j,i}) \quad (1)$$

Wherein, $X_{j,\ kbest,\ i}$ will be the result of a teacher for a subject j. T_F is the teaching factor, deciding the value of the mean that has to be changed, and ri will be the random number within the range [0, 1]. The value for the T_F may be either 1 or 2. The T_F value is randomly decided by an equal probability (2):

$$T_F = round[1 + rand(0,1)\{2-1\}] \quad (2)$$

Wherein rand refers to a random number falling within the range [0, 1]. T_F will not be a parameter of the TLBO. T_F value is not given in the form of an input to the algorithm, and for this, the value is decided in a random manner by the algorithm with Equation (2).

On the basis of the Difference_Mean$_{j,\ i}$, the current solution gets updated in its teacher phase in accordance with the expression (3) below:

$$X'_{j,k,i} = X_{j,k,i} + Difference\_Mean_{j,i} \quad (3)$$

Wherein $X'_{j,k,i}$ will be the updated value of $X_{j,k,i}$. Accept $X'_{j,k,i}$ and in case it provides a better function value. The newly accepted function values at the end of the teacher phase will be maintained, and the values and this is not the input.

It is important to note that the values of r_i and T_F can affect the actual performance of the TLBO. r_i will be the random number within the range [0, 1], and T_F will be the teaching factor. But the values for both r_i and T_F will be randomly generated in this algorithm, and the parameters have not been supplied as an input to this algorithm (unlike in the case of a supply of mutation and crossover probability in the GA, cognitive parameters, social parameters, and inertia weight for the PSO, and the size of the colony in the ABC). So, tuning of ri and T_F will not be needed by the TLBO algorithm as it will require the tuning of some parameters of control that aresimilar to the generations and size of the population. In order to work like this, other common parameters of control were required, and these were based on optimization algorithms. Thus, the TLBO is the algorithm-specific parameter-less algorithm [21].

Learner phase

This was a phase in the algorithm simulating the student can also learn other new information in case the learners are found to have better knowledge. The phenomenon of learning in this phase is as given below:

Randomly choose two different learners, P, and Q, so that $X'_{total-P,i} \neq X'_{total-Q,i}$, wherein, $X'_{total-P,i}$ and $X'_{total-Q,i}$ refer to the updated values of both $X_{total-P,i}$ and $X_{total-Q,i}$, respectively, for the final part of every single teacher phase as in (4 and 5).

$$X''_{j,P,i} = X'_{j,P,i} + r_i(X'_{j,P,i} - X'_{j,Q,i}),\ \text{If}\ X'_{total-P,i} > X'_{total-Q,i} \quad (4)$$

$$X''_{j,P,i} = X'_{j,P,i} + r_i(X'_{j,Q,i} - X'_{j,Q,i}),\ \text{If}\ X'_{total-Q,i} > X'_{total-p,i} \quad (5)$$

(All of the above equations were used for the maximization problems, and the reverse was true for the problems of minimization.)

Accept $X^{"}_{j,P,i}$ in case it is capable of providing better function value.

4 RESULTS AND DISCUSSION

In this section, the TS and TLBO methods are used. The throughput and latency are evaluated for fabrics. Experiments are carried out using a 50 to 200 transaction arrival rate and 1 to 16 channels. The results are shown in tables 1 to 3 and figures 3 to 5.

Table 1: Throughput for TLBO

Transaction Arrival Rate (TPS)	Tabu Search	Teaching Learning Based Optimization
50	7	24
100	49	50
150	74	75
200	96	98

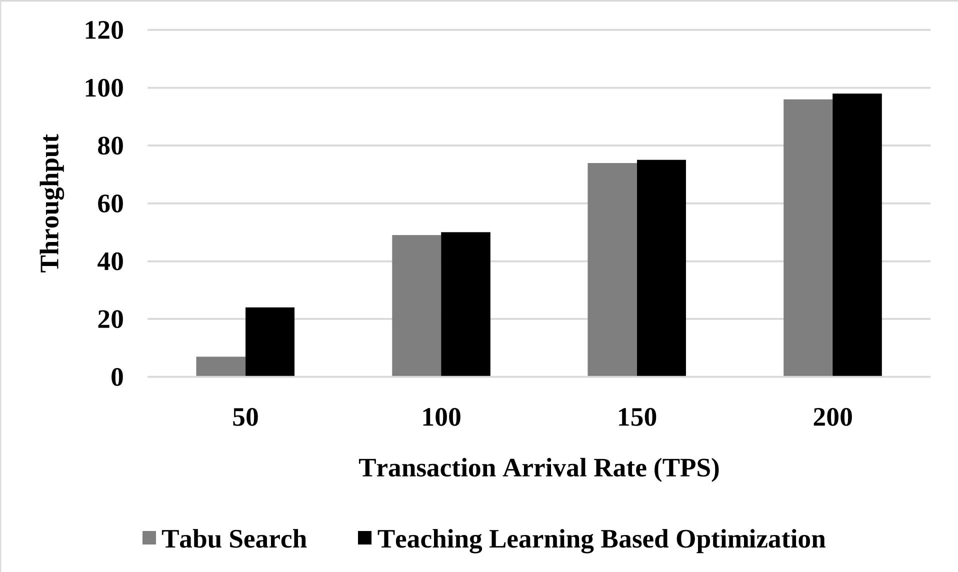

Figure 3: Throughput for TLBO

From the figure 3, it can be observed that the TLBO has higher throughput by 109.67% for 50 transaction arrival rate, by 2.02% for 100 transaction arrival rate, by 1.34% for 150 transaction arrival rate, and by 2.06% for 200 transaction arrival rate when compared with TS respectively.

Table 2: Latency for TLBO

Transaction Arrival Rate (TPS)	Tabu Search	Teaching Learning Based Optimization
50	0.26	0.24
100	0.31	0.29
150	0.47	0.47
200	0.7	0.65

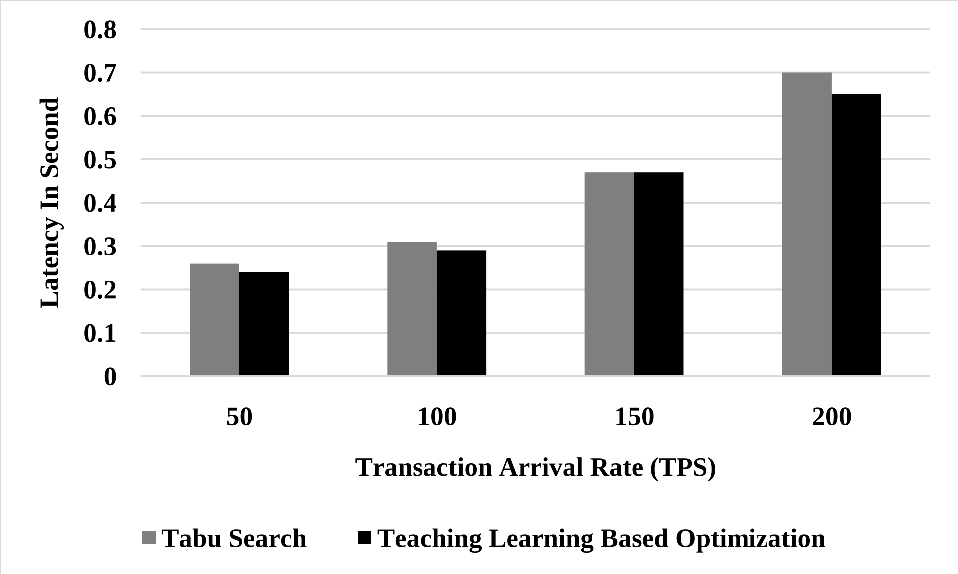

Figure 4: Latency for TLBO

From the figure 4, it can be observed that the TLBO has lower latency by 8% for 50 transaction arrival rate, by 6.67% for 100 transaction arrival rate, by no change for 150 transaction arrival rate, and by 7.41% for 200 transaction arrival rate when compared with TS respectively.

Table 3: Throughput (for block size =100 & Transaction Arrival Rate =100)

Number of channels	Tabu Search	Teaching Learning Based Optimization
1	110	116
2	180	190
4	311	330
8	470	495
16	727	777

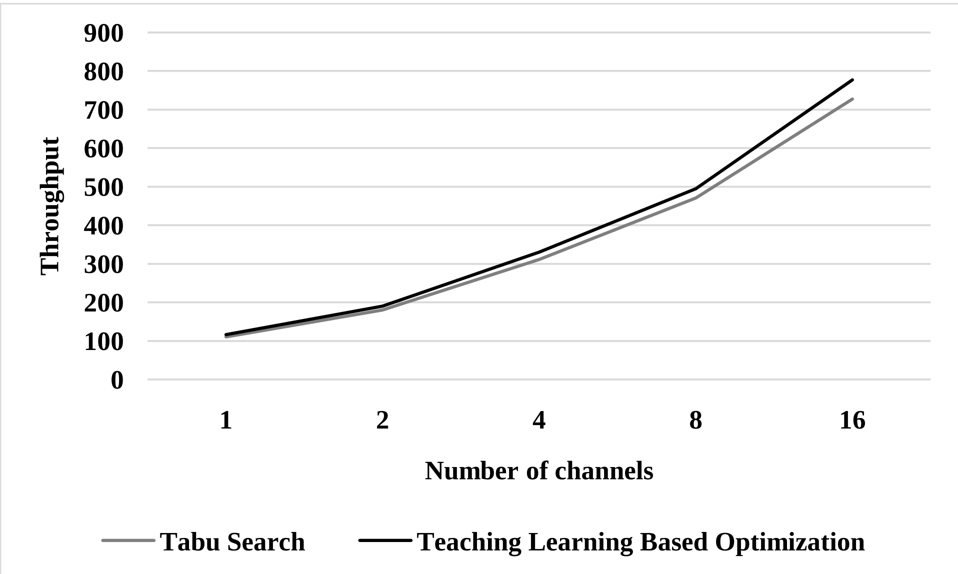

Figure 5: Throughput for TLBO

From the figure 5, it can be observed that the TLBO has higher throughput (for block size =100 & Transaction Arrival Rate =100) by 5.31% for 1 number of channels, by 5.4% for 2 number of channels, by 5.93% for 4 number of channels, by 5.18% for 8 number of channels and by

6.64% for 16 number of channels when compared with TS respectively.

5. CONCLUSION

Blockchain is an attractive technique for future applications. Fabric is another open-source framework that implements the permissioned enterprise-grade blockchain, gaining increased attention. The channel performance and endorsement policy of this block size can be extremely important to the Fabric blockchain while assessing its efficiency. Here, the TS refers to an approach guiding a process of neighbourhood search to facilitate escaping the local optima. The TLBO is a population-based optimization algorithm by passing on the knowledge in a classroom environment, wherein learners learn from the teacher (Teacher Phase) and from classmates (Learner Phase). The TS and TLBO is used to optimize the blocksize to enhance the performance of the blockchain. The results proved that the proposed TLBO has better throughput by 109.67% for the 50 transaction arrival rate, by 2.02% for the 100 transaction arrival rate, by about 1.34% for the 150 transaction arrival rate, and finally, by 2.06% for the 200 transaction arrival rate.

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